3 3 A1-2-14-1

TM 11-5051

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

~~TO 16-35TS-330-5~~

DEPARTMENT OF THE AIR FORCE TECHNICAL ORDER

GUNSTON
W8GQ

CRYSTAL IMPEDANCE METER TS-330/TSM

DEPARTMENT OF THE ARMY • APRIL 1951

DEPARTMENT OF THE ARMY TECHNICAL MANUAL
TM 11-5051

CRYSTAL IMPEDANCE METER TS-330/TSM

DEPARTMENT OF THE ARMY • APRIL 1951

United States Government Printing Office
Washington : 1951

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *4 April 1951*

TM 11-5051 is published for the information and guidance of all concerned.

[AG 413.6 (19 Mar 51)]

BY ORDER OF THE SECRETARY OF THE ARMY:

J. LAWTON COLLINS
Chief of Staff, United States Army

OFFICIAL:
EDWARD F. WITSELL
Major General, USA
The Adjutant General

DISTRIBUTION:

Tech Svc (2) except 11 (65); Arm & Svc Bd (1); AFF Bd (ea Svc Test Sec) (1); AFF (5); AA Comd (2); OS Maj Comd (5); Base Comd (5); MDW (5); Log Comd (5); A (20); CHQ (2); FC (2); Sch (2) except 11 (25); Gen Dep (2); Dep 11 (20) except Sig Sec, Gen Dep (10); Tng Div (2); PE (10), OSD (2); Lab 11 (5); 4th & 5th Ech Maint Shops 11 (3); Two (2) copies to each of the following T/O & E's: 11-107;1 1-127; 11-500 CA, CB, CC, CD; 11-587; 11-592; 11-597; SPECIAL DISTRIBUTION.

For explanation of distribution formula, see SR 310-90-1.

CONTENTS

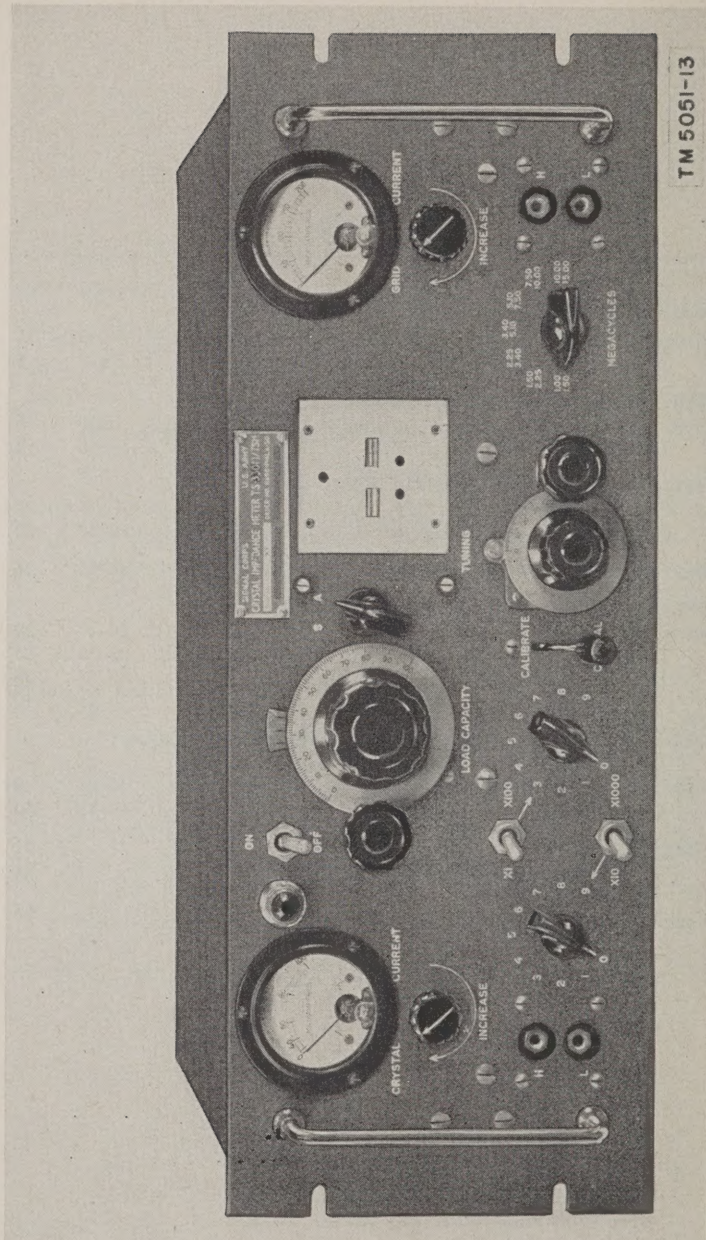


Figure 1. Crystal Impedance Meter TS-330/TSM.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Scope

This manual is published for the information and guidance of personnel to whom this equipment is issued. It contains information on the operation, organizational maintenance, and field maintenance of Crystal Impedance Meter TS–330/TSM (fig. 1).

2. Appendixes

This manual contains two appendixes. Appendix I covers references to other sources of information; appendix II includes an identification table of parts.

3. Forms and Records

The following standard forms will be used for reporting unsatisfactory conditions of equipment, or improper preservation, packaging, packing, marking, loading, stowage, or handling thereof.

a. DD Form 6 will be filled out and forwarded as prescribed in SR 745–45–5 (Army), NAV DEPT SERIAL 85P00 (Navy), and AFR 71–4 (Air Force).

b. DA AGO Form 468 will be filled out and forwarded to the Office of the Chief Signal Officer as prescribed in SR 700–45–5.

c. AF Form 54 will be filled out and forwarded to Commanding General, Air Matériel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR 700–45–5 and AFR 65–26.

d. WD AGO Form 419 will be prepared in accordance with instructions on the back of the form.

e. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

4. Purpose and Use

Crystal Impedance Meter TS–330/TSM (fig. 3) is used to measure the equivalent electrical parameters (fig. 5) of quartz crystals of the type used for communication purposes. The equipment is designed specifically to test quartz crystal units (crystals in holders) for conformance with Military Specifications MIL–C–3098 and MIL–C–10405 and with specified crystal data sheets. Provision is made to

measure directly the effective series-resonant and anti-resonant resistances of a piezoelectric quartz crystal (in its holder). The series capacity C can be computed from the static capacity C_0 of the crystal unit (measured by any l-f (low-frequency) capacity measuring device), the load or input capacity C_1 of the circuit (the value of which is selected by the setting of the capacitor C_{102}), and the resonant and the anti-resonant frequency. In turn the inductance L will be calculated from C and the nominal frequency of the crystal. The PI (performance index) is determined from these electrical parameters of the crystal unit. The PI is a measure of the activity of the crystal

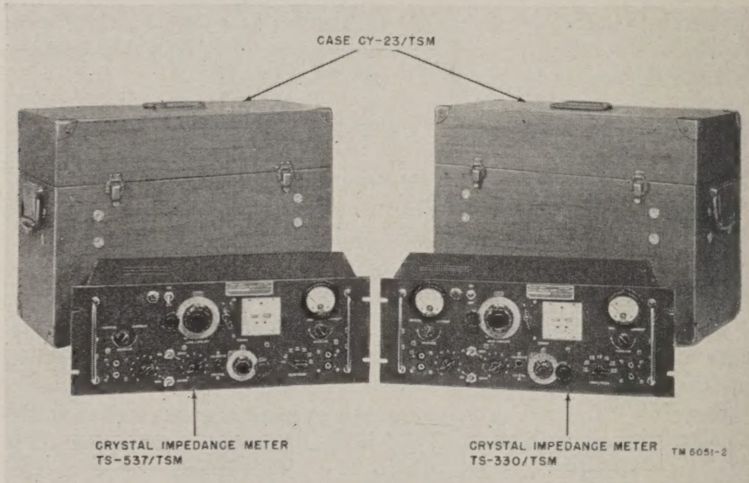


Figure 2. Crystal Test Set AN/TSM–3, components.

under test; the greater the activity of the crystal unit, the more satisfactory its use for communication purposes.

5. Description

a. General. Crystal Impedance Meter TS–330/TSM is one of the major components of Crystal Test Set AN/TSM–3. This test set (fig. 2) consists of Crystal Impedance Meter TS–330/TSM, mounted in Case CY–23/TSM, and Crystal Impedance Meter TS–537/TSM, also mounted in Case CY–23/TSM. The TS–537/TSM is similar to the TS–330/TSM and is used to test crystal units in the frequency range of 75 to 1,100 kc (kilocycles).

b. Crystal Impedance Meter TS–330/TSM. This meter (fig. 3) is used to determine the equivalent electrical parameters of crystal units (crystal oscillator plates mounted in crystal holders) in the frequency range of 1 to 15 mc (megacycles). The CI (crystal impedance) meter is inclosed in a black, wrinkle-finished metal case designed for

rack mounting. The over-all dimensions of the unit are 19 inches long by 10½ inches wide by 7 inches high. The panel contains two ammeters, a crystal socket, jacks, and various controls (par. 11). The CI meter operates from a power source of 115-volt ac (alternating current), 50 to 1,720 cps (cycles per second). Furnished with the meter are a 6-foot, r-f (radio-frequency) pick-up cable assembly with plug attached and a load capacitance calibration chart (par. 13). The CI meter is portable; for carrying purposes, it is placed inside Case CY–23/TSM (which is part of Crystal Test Set AN/TSM–3 (*a* above)).

6. Technical Characteristics

The characteristics of Crystal Impedance Meter TS–330/TSM are as follows:

Frequency range	Seven ranges: 1.00–1.50 mc, 1.50–2.25 mc, 2.25–3.40 mc, 3.40–5.10 mc, 5.10–7.50 mc, 7.50–10.00 mc, 10.00–15.00 mc. Ranges overlap.
Resistance calibration ranges	By use of a toggle switch and two selector switches, the following resistance ranges are obtainable: 0 ohms to 100 ohms in 1-ohm steps, 100 ohms to 990 ohms in 10-ohm steps, 1000 ohms to 9,900 ohms in 100-ohm steps.
Load capacitance calibration	12 to 110 $\mu\mu$f. Dial marked 0–100; a calibration chart is supplied with each unit to translate dial markings to load capacity in $\mu\mu$f.
Required power source	115-volt ac, 50 to 1,720 cps.

7. Packaging Data

a. Crystal Impedance Meter TS–330/TSM. This meter is packed for shipment in a wooden box complying with requirements of Joint Army-Navy specifications as described in JAN–P–100 and JAN–P–116 for oversea packing.

b. Crystal Test Set AN/TSM–3. This equipment is shipped in two Cases CY–23/TSM. Both cases are floated in excelsior in a wooden shipping box.

c. Dimensions and Weights of Packaged Equipment. The dimensions and weights of packaged equipments Crystal Impedance Meter TS–330/TSM, and Crystal Test Set AN/TSM–3, are as follows:

Equipment	Height (in.)	Width (in.)	Depth (in.)	Volume (cu. ft.)	Unit weight (lb.)
Crystal Impedance Meter TS–330/TSM.	20	17	29	5. 7	60
Crystal Test Set AN/TSM–3	35	29	39	23. 0	206

d. Contents of Packing Case. The following list indicates the contents of the packing case. (See the packing list attached to each case for exact contents.

Contents	Notes
1 Crystal Impedance Meter TS–330/TSM	Less tubes.
3 tube, electron: type 6V6GT	Packed inside Meter.
3 tube, electron: type 5Y3GT	Do.
6 tube, electron: type 0C3W	Do.
3 Fuse FU–26: 1 amp, 250 v, glass inclosed	One in equipment, two spares.
3 lamp, incandescent, Sig C Lamp LM–27	Do.
1 cable assembly, RF: pickup	Packed in cover of Case CY–23/TSM.
1 chart, calibration of load capacitance	Do.
2 technical manual for Crystal Impedance Meter TS–330/TSM.	Do.

CHAPTER 2
OPERATING INSTRUCTIONS

Section I. SERVICE UPON RECEIPT OF EQUIPMENT

8. Service upon Receipt of New Equipment

a. UNCRATING, UNPACKING, AND CHECKING. Crystal Impedance Meter TS–330/TSM is shipped in export packing cases. When uncrating and unpacking, be careful not to injure the equipment by thrusting tools into the interior. Do not damage the packing material more than is necessary. Store the inside packaging in the shipping container for future use.

b. STEP-BY-STEP INSTRUCTIONS FOR UNCRATING AND UNPACKING.

(1) Remove the nails with a nail puller and lift off the top of the shipping container.

(2) Cut the tape and seals of the case liner so that the waterproof paper is damaged as little as possible.

(3) Lift out the fiberboard pads used for blocking and bracing the equipment.

(4) Lift out the packaged CI (crystal impedance) meter. Carefully remove the waterproof wrap.

(5) Cut the tape which seals the top flaps of the carton so that the carton is not damaged. Open the carton and remove the moisture-vaporproof package.

(6) Cut off the moisture-vaporproof barrier. Remove the inner carton.

(7) Open the inner box and remove the top cushioning cells and/or pads. Remove the desiccant and packaged technical manuals. Lift out the CI meter.

(8) Store the interior packaging material (except the desiccant) in the inner carton for repacking for storage or shipment. Remove the front panel protection of the CI meter.

(9) Thoroughly inspect the equipment for possible damage during shipment.

(10) Check the contents of the packing case against the master packing slip.

9. Service upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions in paragraph 8 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment for tags or other indications pertaining to changes in the wiring of the equipment.

If any changes in wiring have been made, note the change in this technical manual, preferably on the schematic diagram.

c. Check the operating controls for ease of rotation.

d. Check the equipment for calibration accuracy (ch. 5 sec. IV). Adjust as required.

e. Prepare the equipment for use in accordance with the instructions given in paragraph 10.

10. Preparation for Use

Place the equipment on a bench or in a standard relay rack, and proceed as follows:

a. Check the front panel for chips, cracks, and damaged parts.

b. Check controls and dials for ease of movement and positive action.

c. Remove all dust, dirt, and grease accumulation by wiping with a clean, dry cloth.

d. Place the tubes into their respective sockets.

e. Information concerning the operating procedures is contained in section II of this chapter. Read these instructions carefully before using the equipment.

Section II. OPERATION

11. Panel Controls and Connections

The following table lists the controls and jacks on the front panel of Crystal Impedance Meter TS-330/TSM (fig. 3) and gives their locations and functions; the r-f output connection on the back panel also is discussed.

Control	Location	Function
ON-OFF switch (S108).	Above and to left of LOAD CAPACITY dial.	Switches power on and off when CI meter is connected to power source.
CALIBRATE-CRYSTAL switch (S107).	Below LOAD CAPACITY dail.	The CRYSTAL position is used to switch the crystal into the oscillator feedback circuit. Move the switch to CALIBRATE position after the circuit initially is adjusted to the test crystal, to substitute the equivalent resistance for the unit being tested.
MEGACYCLES switch (S105).	Below and to left of GRID CURRENT meter.	The oscillator may be tuned to any frequency between 1 mc and 15 mc by means of the range selector switch and the oscillator tuning control.
TUNING control (C101).	Below the crystal socket.	The TUNING control is used in connection with the band selector switch noted above for tuning the oscillator to the desired frequency.

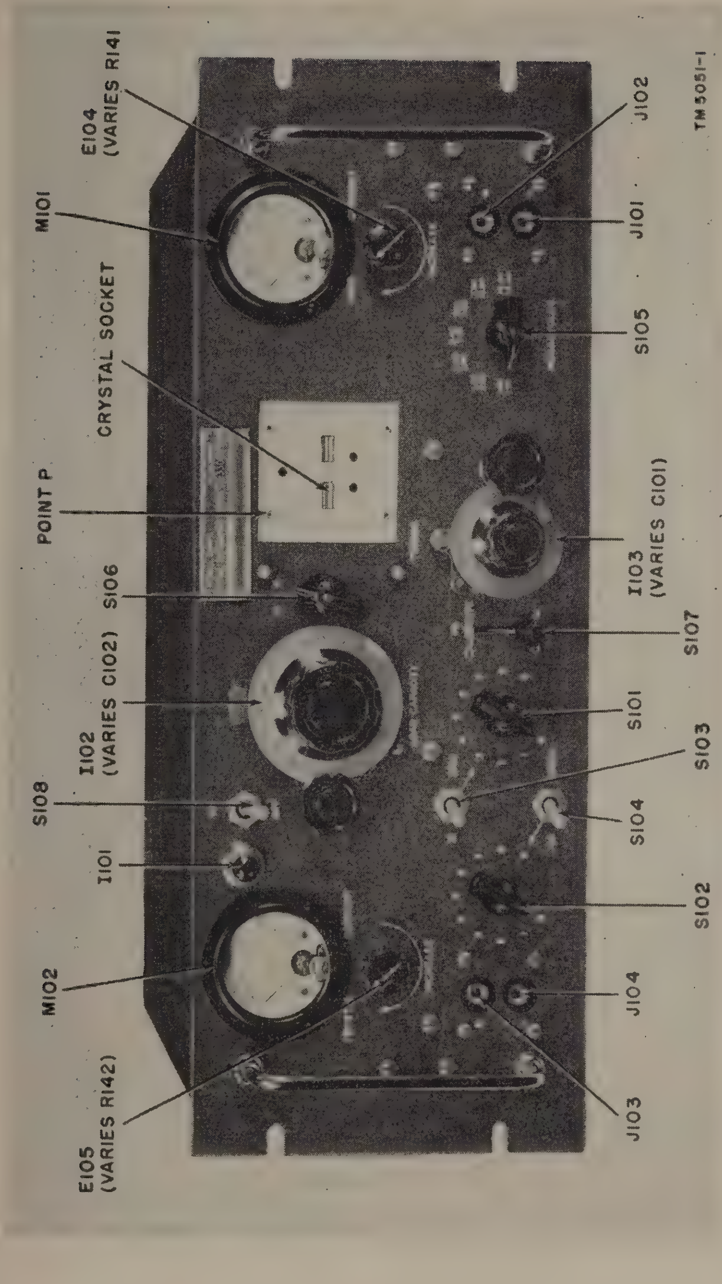


Figure 3. Crystal Impedance Meter TS-330/TSM, panel view.

Control	Location	Function
Crystal socket	Right of LOAD CAPACITY dial.	A two-pin socket with a center-to-center pin spacing of .5 inch to 1.25 inches; Crystal Holder FT–249 may be plugged in for test.
S—A switch (S106).	To right of LOAD CAPACITY dial.	Switches load capacity C102 into circuit position A and short circuits C102 in position S.
LOAD CAPACITY (C102).	Top center of panel.	This control is used for setting the load capacitance (C_1) in anti-resonant operation. Its dial is calibrated and has a vernier drive and indicator. A calibration chart is provided with the equipment to translate the dial reading into capacitance (in $\mu\mu f$).
Decad resistor switches (S101, S102) and range toggle switches (S103, S104).	Lower left, center	These controls consist of two selector switches and two toggle switches. They are used to select a resistance equivalent to the crystal resistance.
CRYSTAL CURRENT control (R142).	Left side of panel	By means of this control, the amount of current passing through the crystal unit under test can be varied.
GRID CURRENT meter (M101).	Right side	The grid current meter is a d-c microammeter used to indicate a convenient proportion of the total rectified grid current.
CRYSTAL CURRENT meter (M102).	Left side	The CRYSTAL CURRENT meter is an r-f thermocouple instrument which measures the magnitude of the r-f crystal current.
GRID CURRENT control (R141).	Right side	This control is used to vary the setting of a shunt resistor across the GRID CURRENT meter, so that convenient readings may be obtained.
Vacuum-tube voltmeter jacks H and L (J101, J102), (J103, J104).	Lower right and left sides of panel.	These jacks provide connections to voltmeters for measurement of voltage across the crystal unit.
Light indicator (I–101).	Left of ON-OFF switch S108.	Incandescent lamp lights when current is flowing through primary of transformer T101.
Coaxial connector receptacle (J105).	Rear of chassis	A coaxial connector receptacle which provides means by which a small portion of the r-f output of the oscillator may be connected (via r-f cable assembly W101) to frequency measuring equipment.

12. Operation Under Usual Conditions

Note. Before making any crystal measurements, the operator must consult the crystal specification sheet. The crystal drive (crystal wattage rating) as measured by the CRYSTAL CURRENT meter must not exceed the level indicated in the specification sheet (if available).

a. MEASUREMENT OF SERIES-RESONANT RESISTANCE.

Caution: To prevent damage to the meter, adjust the CRYSTAL CURRENT and GRID CURRENT controls to their minimum positions (maximum counterclockwise position) before turning the instrument on.

(1) Insert the a-c cable assembly plug P101 into a 115-volt, 50- to 1,720-cps a-c source.

(2) Switch the ON-OFF switch to ON. Allow 15 minutes for warm-up.

(3) Switch the CALIBRATE-CRYSTAL switch to the CRYSTAL position.

(4) Set the MEGACYCLES switch to the proper frequency range.

(5) Turn switch S—A to position S.

(6) Insert the crystal unit in the crystal socket.

(7) Increase the GRID CURRENT control slightly in a clockwise direction.

(8) Adjust the TUNING control for maximum GRID CURRENT meter reading. It may be necessary to increase the GRID CURRENT and the CRYSTAL CURRENT controls to obtain a convenient GRID CURRENT meter reading. The crystal current, as indicated on CRYSTAL CURRENT meter M102, should be held as small as possible or as specified in the note above with the sensitivity of the GRID CURRENT meter at maximum.

 Caution: Do not increase the CRYSTAL CURRENT control more than is necessary, because damage to crystal and equipment may result.

(9) Connect the cable assembly W101 from J105 to a radio receiver equipped with a bfo (beat-frequency oscillator). Obtain an approximate measurement of the crystal frequency by zero-beating the signal of the oscillator of the CI meter with the signal of the bfo. Read the frequency from the receiver tuning dial or calibration chart (ch. 4).

(10) Use switches S103 and S104, and set the decade resistors to the maximum specified resistance for the particular crystal under test.

(11) Switch the CALIBRATE-CRYSTAL switch to the CALIBRATE position. If the GRID CURRENT meter needle goes off-scale, immediately switch enough resistance (by means of the decade resistors) into the circuit to bring the

GRID CURRENT meter reading back to the value obtained in the CRYSTAL position.

(12) Adjust the TUNING control so that the signal is at zero beat with the frequency measured in (9) above.

(13) Move the CALIBRATE-CRYSTAL switch to the CRYSTAL position.

(14) Adjust the GRID CURRENT control to obtain any convenient value of meter reading. This adjustment should remain fixed throughout the remainder of the test.

(15) Switch to the CALIBRATE position.

(16) Adjust the decade resistors to obtain the same value of GRID CURRENT meter reading as when the CALIBRATE-CRYSTAL switch was in the CRYSTAL position ((14) above).

(17) Readjust the TUNING control to obtain the same frequency as in the CRYSTAL position ((9) above).

(18) Repeat steps given in (16) and (17) above, if necessary, to obtain identical grid current and frequency values in both CALIBRATE and CRYSTAL positions.

(19) Read the value of resistance from the settings of the decade resistors. This is the effective series-resonant resistance of the crystal unit.

(20) Move the CALIBRATE-CRYSTAL switch to the CRYSTAL position. Make an accurate measurement of the operating frequency by connecting cable assembly W101 to an appropriate frequency-measuring instrument such as the following: Frequency Meter FR–4, Frequency Measuring Assembly CY–93/FSM–1 (described in TM 11–2606), or Frequency Meter SCR–211; selection of the meter to be used depends on the intended use and the accuracy desired (ch. 4).

b. Measurement of Anti-Resonant Resistance.

Caution: To prevent damage to the meter, adjust the CRYSTAL CURRENT and GRID CURRENT meter controls to their minimum positions (maximum counterclockwise position) before turning the instrument on.

(1) Insert the a-c cable assembly plug P101 into a 115-volt, a-c source.

(2) Switch the ON-OFF switch to ON. Allow 15 minutes for warm-up.

(3) Switch the CALIBRATE-CRYSTAL switch to the CRYSTAL position.

(4) Set the MEGACYCLES switch to the frequency range of the crystal.

(5) Turn switch S—A to position S.

(6) Adjust the LOAD CAPACITY dial to the proper setting. Calibration data are given in the calibration chart (par. 13) supplied with the instrument.
(7) Insert the crystal unit in the crystal socket.
(8) Increase the GRID CURRENT control slightly in a clockwise direction.
(9) Adjust the TUNING control for maximum GRID CURRENT meter reading. It may be necessary to increase the GRID CURRENT and the CRYSTAL CURRENT controls to obtain a convenient GRID CURRENT meter reading. The crystal current as indicated by CRYSTAL CURRENT meter M102 should be held as low as possible with the GRID CURRENT control knob at maximum clockwise position. See note at beginning of this paragraph.

    Caution: Do not increase the CRYSTAL CURRENT control more than is necessary, because damage to crystal and equipment may result.
(10) Turn switch S—A to position A.
(11) Connect the cable assembly W101 from J105 to a radio receiver equipped with a bfo. Obtain an approximate measurement of the crystal frequency by zero-beating the signal of the oscillator of the CI meter with the signal of the bfo. Read the frequency from the receiver tuning dial or calibration chart (ch. 4).
(12) Set the decade resistors to the maximum specified resistance for the particular crystal under test with Switches S–103 and S–104.
(13) Switch the CALIBRATE-CRYSTAL switch to the CALIBRATE position. If the GRID CURRENT meter goes off-scale, immediately switch enough resistance (by means of the decade resistors) into the circuit to bring the GRID CURRENT meter reading back to the setting obtained in the CRYSTAL position.
(14) Adjust the TUNING control so that the signal is at zero beat with the frequency measured in (11) above.
(15) Switch the CALIBRATE-CRYSTAL switch to the CRYSTAL position.
(16) Adjust the GRID CURRENT control to obtain any convenient value of meter reading. This adjustment should remain fixed throughout the remainder of the test.
(17) Move the CALIBRATE-CRYSTAL switch to the CALIBRATE position.
(18) Adjust the decade resistor to obtain the same value of the GRID CURRENT meter reading as when the CALIBRATE-CRYSTAL switch was in the CRYSTAL position.

(19) Readjust the TUNING control to the same frequency as in the CRYSTAL position.

(20) Repeat steps in (18) and (19) above, if necessary, to obtain identical grid current and frequency values in both the CALIBRATE and the CRYSTAL positions.

(21) Read the value of resistance from the settings of the decade resistors. This is the effective anti-resonant resistance of the crystal unit.

(22) Move the CALIBRATE-CRYSTAL switch to the CRYSTAL position. Make an accurate measurement of operating frequency (*a* (20) above). This value is the anti-resonant frequency (ch. 4).

c. Procedure for Using CI Meter as a Go-No-Go Gage, Anti-Resonant Operation.

(1) Insert the a-c cable assembly (W102) plug into a 115-volt a-c source.

(2) Switch the ON-OFF switch to ON. Allow 15 minutes for warm-up.

(3) Adjust the crystal drive (crystal wattage rating) according to information given in the specification which covers the particular crystal unit under test. Where no drive level has been established, the crystal should be maintained at as low a level as possible. To accomplish this, advance the GRID CURRENT control to its extreme clockwise position, and then advance the CRYSTAL CURRENT control to that position which will give a convenient GRID CURRENT meter reading.

(4) Turn the S–A switch to the A position.

(5) Adjust the LOAD CAPACITY dial to the proper setting. Calibration data are given in the calibration chart (par. 13) supplied with the instrument.

(6) Set the MEGACYCLES switch to the frequency range of the crystal.

(7) Set the CALIBRATE-CRYSTAL switch to the CRYSTAL position.

(8) Insert the crystal unit in the crystal socket.

(9) Adjust the TUNING control for maximum GRID CURRENT meter reading. It may be necessary to adjust the GRID CURRENT control in order to obtain a convenient GRID CURRENT reading.

Caution: Do not disturb the CRYSTAL CURRENT control; this should remain fixed ((3) above) for the remainder of the test.

(10) Connect the cable assembly W101 from J105 to a radio receiver equipped with a bfo. Obtain an approximate measure-

ment of the crystal frequency by zero-beating the signal of the oscillator of the CI meter with the signal of the bfo; read the frequency from the receiver tuning dial or calibration chart (ch. 4).

(11) Set the CALIBRATE-CRYSTAL switch to the CALIBRATE position.

(12) Adjust the decade resistors to the value which corresponds to the maximum permissible resistance for the frequency desired as indicated in the applicable crystal unit specification.

(13) Adjust the TUNING control so that the signal is at or near zero beat with the frequency measured in (10) above.

(14) Adjust the GRID CURRENT control to obtain any convenient value of GRID CURRENT meter reading. This adjustment should remain fixed throughout the remainder of the test.

(15) Note the GRID CURRENT value. This value is the passing activity level.

(16) Set the CALIBRATE-CRYSTAL switch to the CRYSTAL position.

(17) Crystals exhibiting a greater GRID CURRENT meter reading than was obtained in (15) above pass the activity requirements; those showing less, fail.

(18) The above procedure must be repeated each time the crystal unit frequency is changed.

d. Procedure for Using CI Meter as a Go-No-Go Gage, Series-Resonant Operation.

(1) Insert the a-c cable assembly (W102) plug into a 115-volt a-c source.

(2) Switch the ON-OFF switch to ON. Allow 15 minutes for warm-up.

(3) Adjust the crystal drive according to information given in the specification covering the particular crystal unit under test. Where no drive level has been established, the crystal should be maintained at as low a level as possible. To accomplish this, advance the GRID CURRENT control to its extreme clockwise position, and then advance the CRYSTAL CURRENT control to that position which will give an adequate current reading.

(4) Turn the S–A switch to the S position.

(5) Set the MEGACYCLES switch to the proper frequency range.

(6) Set the CALIBRATE-CRYSTAL switch to the CRYSTAL position.

(7) Insert the crystal unit in the crystal socket.

(8) Adjust the TUNING control for maximum GRID CURRENT meter reading. It may be necessary to adjust the GRID CURRENT control to obtain a convenient GRID CURRENT meter reading.

Caution: Do not disturb the CRYSTAL CURRENT control because this should remain fixed ((3) above) for the remainder of the test.

(9) Connect the cable assembly W101 from J105 to a radio receiver equipped with a bfo. Obtain an approximate measurement of the crystal frequency by zero-beating the signal of the oscillator of the CI meter with the signal of the bfo; read the frequency from the receiver tuning dial or calibration chart (ch. 4).

(10) Set the CALIBRATE-CRYSTAL switch to the CALIBRATE position.

(11) Adjust the decade resistors to the value which corresponds to the maximum permissible resistance for the frequency desired as indicated in the applicable crystal unit specification.

(12) Adjust the TUNING control so that the signal is at or near zero beat with the frequency measured in (9) above.

(13) Adjust the GRID CURRENT control to obtain any convenient value of meter reading. This adjustment should remain fixed throughout the remainder of the test.

(14) Note the GRID CURRENT value. This value is the passing activity level.

(15) Set the CALIBRATE-CRYSTAL switch to the CRYSTAL position.

(16) Crystals exhibiting a greater GRID CURRENT meter reading than obtained in (14) above pass the activity requirements; those showing less, fail.

(17) This procedure must be repeated each time the crystal unit frequency is changed.

e. Operating Instructions for Using CI Meter With Crystal Test Block at Anti-Resonance. If it is desired to temperature-cycle (TM 11-2540) individual crystals operating at anti-resonance with a given value of load capacitance, use a test block, or equivalent, containing a padding capacitor mounted in series with one of the crystal leads. Proceed as follows:

(1) Find the exact frequency of crystal unit under test, as outlined in the anti-resonant test procedure in *b* above.

(2) Remove the crystal from the socket and insert it in the test block. Insert the test block in the crystal socket.

(3) Turn the switch S–A to position S.

(4) Adjust the trimmer capacitor in the crystal test block until the frequency of the crystal is precisely the same as the frequency found in (1) above. The test block now is ready for operation.

f. Operational Instructions for Using CI Meter With Crystal Test Block at Series Resonance. If it is desired to temperature-cycle (TM 11–2540) individual crystals operating at series resonance, use a temperature test block without a series padding capacitor. Proceed as follows:

(1) Insert the crystal test block in the crystal socket.

(2) Turn switch S—A to position S.

(3) Insert the crystal in the test block. The block is now ready for use.

13. Calibration Chart for LOAD CAPACITY Dial

This chart is prepared especially for each particular CI meter; see that the serial number on the chart corresponds to that on the equipment. The LOAD CAPACITY dial (I–102) is marked with numbers from 0 to 100. These markings are translated into $\mu\mu$f (micromicrofarads) by means of a chart (fig. 4) supplied with each equipment. To obtain the value of load capacity (in $\mu\mu$f) proceed as follows:

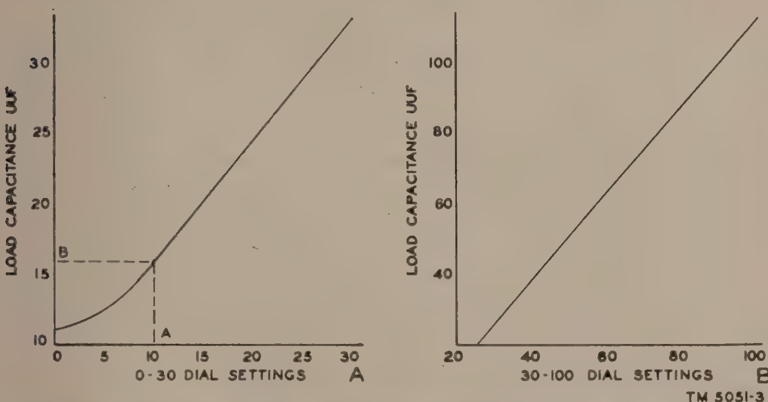


Figure 4. Calibration chart for determination of load capacitance from dial settings.

a. Locate the dial setting on the abscissa of the chart (point A).

b. Trace this value to the curve.

c. Find the equivalent ordinate value (point B). This is the value of the load capacity in $\mu\mu$f.

14. Crystal Parameters

a. GENERAL.

(1) *Piezoelectric effect.* When an electrical stress is applied to a cut quartz crystal in the direction of one of the major axes, a mechanical stress is produced at right angles to this axis. Conversely, a mechanical stress along a major axis will cause electrical charges to appear on the faces of the crystal perpendicular to the stress axis. The polarity of the electrical stress and the direction of the corresponding mechanical force are interrelated, a reversal in one causes a reversal in the other. This relationship between electrical stress and mechanical force is termed the piezoelectric effect and provides a means of relating mechanical vibrations to electrical circuits.

(2) *Resonance.* An alternating voltage applied across a quartz crystal will cause the crystal to vibrate; if the frequency of the applied alternating voltage approximates a frequency at which mechanical resonance can exist in the crystal, the amplitude of the vibrations will be very large. Any crystal has several such resonant frequencies that depend on the crystal dimensions, the type of oscillation involved, and the orientation of the plate cut from the natural crystal.

(3) *Properties of piezoelectric resonator.* A good piezoelectric resonator possesses the following properties: a low-temperature coefficient of resonant frequency, a high piezoelectric activity (performance index), and a frequency spectrum containing only one resonant frequency in the vicinity of the desired oscillation. Temperature can alter the frequency of mechanical resonance through its effects on the density, the linear dimensions, and the moduli of elasticity of the crystal. Since some of the elastic constants are positive and others are negative, the temperature coefficient of frequency may be either positive, negative, or zero, according to the mode of oscillation, the orientation of the crystal plate, and the shape of the plate. The electrical circuit associated with a vibrating crystal is shown in figure 5. The capacity C_o, represents the electrostatic capacity between the crystal electrodes when the crystal is in place but not vibrating; the series comination of L, C, and R represents the equivalent mass, compliance, and frictional loss of the vibrating crystal, respectively. Read TM 11–2540 for more detailed information on this subject.

b. MEASUREMENT.

(1) *Static capacity C_o.* The value of the static capacity of the crystal unit C_o may be measured by any conventional capacitance measuring unit. If this measurement is made with

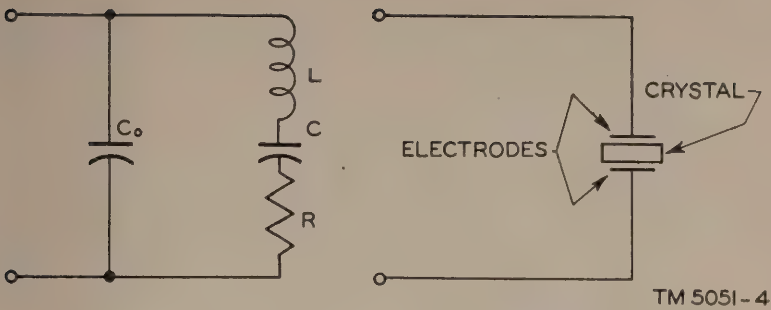


Figure 5. Equivalent electrical circuit of a piezoelectric crystal.

the use of a Q meter or an r-f bridge, be careful to select a frequency of operation somewhat lower than the crystal unit frequency. Figure 5 shows a diagram of the parameters of a piezoelectric crystal:

(2) *Series-resonant and anti-resonant resistances.* The measurement of the effective resistance in ohms at series resonance is outlined in the operational procedure (par. 12*a*). The measurement of effective resistance in ohms at anti-resonance is outlined in the operational procedure (par. 12*b*).

(3) *Series capacity, C.* Use the following equation to calculate the capacity C of the series arm of the crystal:

$$C \text{ (in Farads)} = \frac{2\,(C_o + C_1)\,\Delta F}{F}$$

where:

ΔF = the difference between the anti-resonant frequency and the series-resonant frequency (F_a-F_s) in cps,
F = the nominal frequency of the crystal unit in cps,
C_o = the static capacity of the crystal unit in farads, and
C_1 = The load capacity in farads.

(4) *Inductance, L.* Use the following equation to calculate inductance, L, in the series arm of the crystal:

$$L \text{ (in henries)} = \frac{1}{(2\pi F)^2 C}$$

where:

F = the nominal frequency of the crystal unit in cps, and
C = the series capacity C of the crystal unit in farads.

(5) *Voltage across the crystal unit.* Two pairs of jacks are provided on the front panel for the measurement of voltage across the crystal unit. Two vacuum-tube voltmeters such as Electronic Multimeter TS–505/U may be used for this measurement. The r-f current through the crystal unit as measured by CRYSTAL CURRENT meter M102 also may

be used for voltage determination. Series resonance and anti-resonance present two different cases, as follows:

(a) *Series resonance.*

$$E=E_1=RI$$

where:

E=voltage across the crystal,

E_d=difference between the two voltmeter readings,

R=effective series-resonant resistance in ohms (par. 12*a*), and

I=r-f crystal current in amperes.

(b) *Anti-resonant resistance.*

$$E=\frac{E_d}{2\pi FC_1R_e}=\frac{I}{2\pi FC_1}$$

where:

F=Nominal frequency of the crystal unit in cps,

C_1=load capacity in farads, and

R_e=effective anti-resonant resistance in ohms (par. 12*b*).

(6) *PI* (*performance index*). The *PI* of the crystal unit also may be calculated from the equation:

$$PI=\frac{X_e^2}{R_e}=\frac{1}{(2\pi FC_1)^2R_e}$$

where:

$$X_e=\frac{1}{2\pi FC_1}$$

15. Equipment Performance Checklist

a. General. The equipment performance checklist aids in determining whether Crystal Impedance Meter TS–330/TSM is functioning properly. This checklist gives the item to be checked, the action or condition under which it is checked, the normal indications of correct operation (what should happen), and the corrective measures (what to do) the operator may take.

b. Action or Condition. The information given in the *Action or condition* column represents an action that must be taken to check the normal indication given in the *Normal indication* column.

c. Normal Indication. The normal indications listed include the visible signs that the operator will find when he checks the items. Apply the recommended corrective measures if the indications are not normal.

d. Corrective Measure. When normal indications are not present, the operator may perform the corrective measures listed. If the set is completely inoperative or if the recommended corrective measures do not yield results, refer to chapter 5.

e. Equipment Performance Checklist. Use this checklist to determine whether the equipment is performing properly. Refer to paragraph 12 for step-by-step operating procedures.

Item No.	Item	Action or condition	Normal indication	Corrective measure
1	ON-OFF switch (S108)	Turn switch to ON position	Pilot lamp lights	See that the power cable assembly (W102) is connected to the proper power source. Check fuse. Check lamp.
2	CALIBRATE-CRYSTAL switch (S107).	Turn to CALIBRATE. Increase CRYSTAL CALIBRATE control. Increase GRID CURRENT control. Set decade resistor switches (S101, S102) at zero. Turn S–A switch to S.	GRID CURRENT meter indication.	See chapter 5, section III, for trouble-shooting.

16. Operation under Unusual Conditions

Operation of Crystal Impedance Meter TS-330/TSM in tropical, Arctic, or desert region, where extremes of temperature and humidity often occur, involves problems which require special care of the equipment. In most cases, this special care must be determined by the particular installation and resultant degree of exposure to these severe conditions. For information covering the special treatment of equipment to these conditions, refer to chapter 3, section I.

CHAPTER 3
MAINTENANCE INSTRUCTIONS

Section I. PRESERVATION

Note. Lubrication is not required for Crystal Impedance Meter TS–330/TSM.

17. Weatherproofing

a. GENERAL. Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, Arctic, and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials. Observe all precautions outlined in TB SIG 123.

b. TROPICAL MAINTENANCE. A special moistureproofing and fungiproofing treatment has been applied to the equipment which provides a reasonable degree of protection. This treatment is explained fully in TB SIG 13 and TB SIG 72.

c. WINTER MAINTENANCE. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained fully in TB SIG 66 and TB SIG 219.

d. DESERT MAINTENANCE. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained fully in TB SIG 75.

18. Rustproofing and Painting

a. Whenever the finish on the cabinet has been badly scarred or damaged, touch up the bared surface to prevent rust and corrosion. Use No. 00 or No. 000 sandpaper to clean the surface down to the bare metal; obtain a bright smooth finish. For severe rust use solvent (SD) to soften the rust and then use sandpaper to remove the rust.

Caution: Do not use steel wool or emery cloth instead of sandpaper. Minute particles of conducting material may enter the cabinet and cause shorting or grounding of circuits.

b. Before repainting, touch up bared metal parts with a prime coat and allow it to dry. When a touch-up is needed, apply paint with a small brush. Do not remove any electrical parts to accomplish the painting.

Section II. PREVENTIVE MAINTENANCE SERVICES

19. Definition and Importance

a. DEFINITION. Preventive maintenance is a systematic series of operations performed at regular intervals on equipment to minimize major breakdowns and unwanted interruptions in service, and to maintain equipment at top operating efficiency.

b. IMPORTANCE. Through these systematic inspections, personnel charged with the care of the equipment should be able to detect abnormal conditions and possible sources of trouble, and correct them before major troubles or breakdowns occur.

20. Tools and Materials

The tools and materials listed below are used in performing preventive maintenance on Crystal Impedance Meter TS–330/TSM and must be on hand before preventive maintenance action is taken.

Signal Corps stock No.	Name and description
	Common hand tools.
6G184.1	Carbon tetrachloride: 8-oz metal can.
6Z2056	Cloth: lint-free; 6″ x 9″; twill-jean.
6Z7500–0000	Paper: sand; No. 0000, 9″ x 11″ sheets.
6G1516	Polish: paste, metal.
*	Solvent, dry-cleaning (SD).

*Quartermaster Corps No. 51–S–4385–1. Air Force activities consult T. O. No. 16–1–73 and supplements for list of approved solvents for cleaning communications equipment. Gasoline will not be used as a cleaning fluid for any purpose.

21. Preventive Maintenance Techniques

a. Use No. 0000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning.

(1) If necessary, except for electrical contacts, moisten the cloth or brush with solvent (SD); then wipe the parts dry with a cloth.

(2) Clean electrical contacts with a cloth moistened with carbon tetrachloride; then wipe them dry with a dry cloth.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 psi (pounds per square inch) to remove dust from inaccessible places; be careful, however, or mechanical damage from the air blast may result.

d. For further information on preventive maintenance techniques, refer to TB SIG 123.

22. Preventive Maintenance Checklist

The following checklist is a summary of the preventive maintenance operations that must be performed on Crystal Impedance Meter TS-330/TSM. The list indicates what to check, when to check, how to check, and what precautions to take before, during, and after checking the equipment.

Item No.	What to check	When to check*	How to check	Precautions
1	Crystal impedance meter exterior and panel.	D	Inspect for damage, chipped paint, dirt, dust, rust, corrosion, loose or missing screws. Wipe with clean cloth slightly moistened with solvent (SD) to remove oil, grease, or foreign matter. Wipe with dry cloth.	Tighten screws snugly; never force them.
2	Connector receptacles J101, J102, J103, and J104.	W	Lift out operating panel from case by taking out the four mounting screws. Inspect the receptacles for dirt, dust, and other foreign matter. Be sure receptacles are tightly fastened. Clean with solvent (SD) and a clean, dry cloth.	Do not tighten receptacle screws more than necessary; never force them.
3	Controls	D	Inspect for freedom of action. See that only a normal amount of pressure is required to operate them. Be certain knobs are not loose.	Do not overtighten screws holding knobs.
4	Interior	M	Inspect wiring and other parts for defects. Check contacts of keys and switches for dirt, dust, or foreign matter. Look for corrosion and rust. See that all solder joints are secure. Check screws, nuts, and bolts. Tighten screw-type terminals. Blow dust or dirt from interior with an air hose.	Do not overtighten screws, nuts, and bolts. If it is necessary to resolder, be sure no loose solder falls between other parts; this causes shorts.

5	Cable assemblies and plugs	W	Inspect cable assemblies for dirt, dust, mildew, and fungus growth. Inspect plugs for corrosion and loose connections. Clean cable assemblies with a clean, dry cloth, by wiping off dirt, dust, and foreign matter. If grease is on cable assemblies, use solvent (SD). Clean plugs with polish, paste, and metal.	Never use soap and water when cleaning cable assemblies and plugs. Never use gasoline or other inflammable materials.
6	Switch contacts	M	After a prolonged period of inactivity, the switch contacts may become corroded. Clean them with sandpaper, No. 0000.	Do not use emery cloth; the abrasive particles are conductive.

*D—daily. W—weekly. M—monthly.

CHAPTER 4

AUXILIARY EQUIPMENT

23. Frequency Measurement Equipment

a. STANDARD FREQUENCY TEST RACK. The CI meter is coupled to a standard frequency test rack to measure the exact frequency of crystal units. The standard frequency test rack consists of the items listed below; other frequency test equipment consists of similar items.

(1) Bfo radio receiver.
(2) Selected inductance coil (and its associated coil graph) for use in the bfo receiver.
(3) Oscilloscope.
(4) Interpolation oscillator.
(5) Power pack.
(6) Loudspeaker.
(7) Multivibrator unit.
(8) Antenna.
(9) Power supply.

b. ALTERNATE EQUIPMENT. Alternate frequency measuring equipment may be used in place of that listed in *a* above but with less accurate results.

(1) A calibrated radio receiver may be used. The degree of accuracy will be low, however, because of the frequency variation that is commonly found in such radio circuits.
(2) Frequency Meter Set SCR–211 may be used in an emergency to supply the frequency standard in place of the multivibrator unit or interpolation oscillator. Its main function, however, is to tune and to calibrate radio receivers in a net to a given frequency. When available, the FR–4/U and FR–5/U Frequency Meters should be used instead of Frequency Meter Set SCR–211.
(3) A comparison oscillator and deviation meter may be substituted for the interpolation oscillator. Lack of frequency stability and accuracy of calibration make this equipment less desirable than the interpolation oscillator.

24. Procedure for Measuring Accurate Frequencies

The frequency of crystal units can be determined accurately by coupling the CI meter to a standard frequency test rack (fig. 6), Frequency Measuring Assembly CY–93/FSM–1, or similar frequency

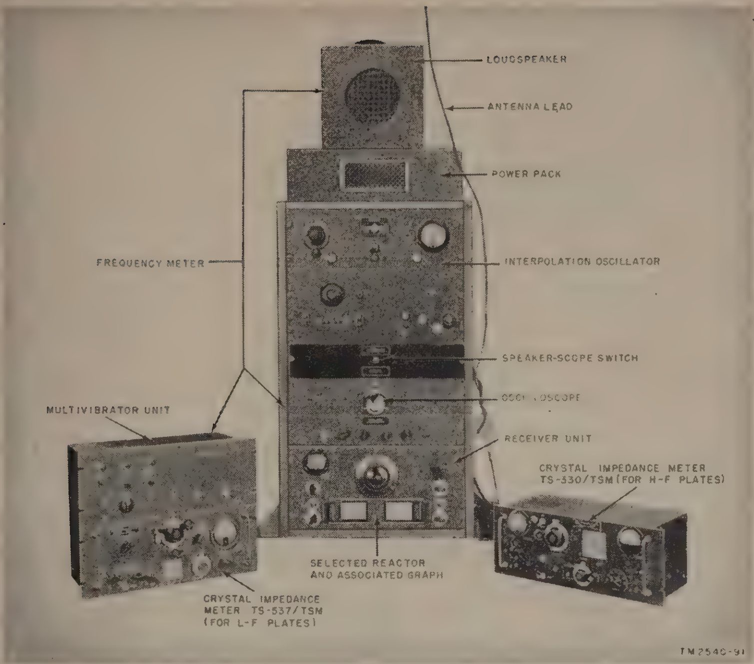


Figure 6. Crystal resistance and frequency measuring equipment.

measuring equipment. The operating procedure will vary according to the equipment used, but is essentially as follows:

a. The crystal unit is plugged into the CI meter which is coupled to the frequency test equipment by means of a coaxial cable connected to the antenna post of the bfo of the radio receiver.

b. The receiver is adjusted for c-w (continuous-wave) operation and the crystal unit is tuned in; the dial setting is noted.

c. The crystal unit is turned off, and the receiver is tuned to the standard signal (harmonic of WWV) nearest the above dial setting.

d. The bfo in the receiver is turned off, and the CI meter with the crystal unit under test is turned on.

e. The audio beat note (TM 11–2540) is measured by means of the audio (or interpolation) oscillator and the loudspeaker or scope. If the loudspeaker is used, the audio beat note is noted by ear. If the scope is used, the audio oscillator is set to deliver a signal to the scope. A fluttering image will be seen on the screen of the oscilloscope when the two frequencies are nearly the same. This image changes to a circular one as the audio generator frequency is varied slowly and made the same as the beat-note frequency.

f. When the circular image is secured, the beat frequency can be read on the scale of the bfo. The beat-note frequency is added to or subtracted from the frequency of the interpolation oscillator signal in order to get the exact frequency of the crystal unit under test.

g. To determine whether the frequency of the audio note is to be added to or subtracted from the crystal unit, capacitance is added in series to lower the frequency of the crystal unit. If the audio beat note increases in pitch, then it is known that the frequency difference between the two signals has increased and that the frequency of the crystal unit is lower than that of the interpolation oscillator, and the frequency of the audio beat note then is subtracted from the standard signal. However, if the audio beat note decreases in pitch, then it is known that the frequency difference between the two signals has become smaller and that the frequency of the crystal unit is higher than that of the interpolation oscillator. The frequency of the audio beat note is added to the frequency of the interpolation oscillator.

25. References

For detailed information on frequency test equipment, refer to the following publications:

TM 11–2540____	Quartz Crystals—Theory, Fabrication, and Performance Measurements.
TM 11–2530____	Frequency Standard TS–308/U.
TM 11–2606____	Test Set AN/FSM–3, Tool Equipment TK–40/FSM–3, and Maintenance Kit MK–40/FSM–3 (Formerly Depot Crystal Equipment AN/FSM–1).

CHAPTER 5

FIELD MAINTENANCE INSTRUCTIONS

Section I. THEORY OF OPERATION

26. General

Crystal Impedance Meter TS–330/TSM measures the equivalent circuit parameters of a piezoelectric crystal in the frequency range of 1.0 to 15.0 mc. The CI meter consists of a single r-f beam power oscillator, a feedback network (fig. 10), and a conventional power supply (fig. 9). The crystal under test or a dedade resistor can be made part of the feedback network. The magnitude of the oscillations of the tube is indicated by the GRID CURRENT meter.

27. Functioning of Crystal Impedance Meter TS–330/TSM

a. General.

(1) The crystal impedance meter is essentially a tuned-grid, tuned-plate oscillator circuit (figs. 8 and 10) in which the crystal unit to be tested is placed in the feedback path. The crystal unit thus controls the oscillation frequency of the circuit and the amplitude of oscillation. The effective resistance of the crystal unit is measured by application of the following principle of substitution: In any system, if an element of the system is removed and a substitute element is inserted in its place so that the original set of boundary conditions is satisfied and no new ones are added, then the substitute element is equivalent operationally to the original element. Thus, the boundary conditions (oscillation frequency and amplitude of oscillation) are measured at some point in the circuit; a network of resistance and reactance is substituted for the crystal unit without changing the boundary conditions; then the network represents the crystal unit at that particular frequency and amplitude of oscillation. The crystal unit may be operated at either series resonant frequency or at antiresonant frequency.

(2) At series resonance, the equivalent electrical circuit (fig. 5) of the crystal unit is purely resistive. At antiresonance, the equivalent electrical circuit of the crystal unit is inductive. Thus, the crystal unit is operated at antiresonant frequency, and if the correct value of load capacitance (C_1) is connected

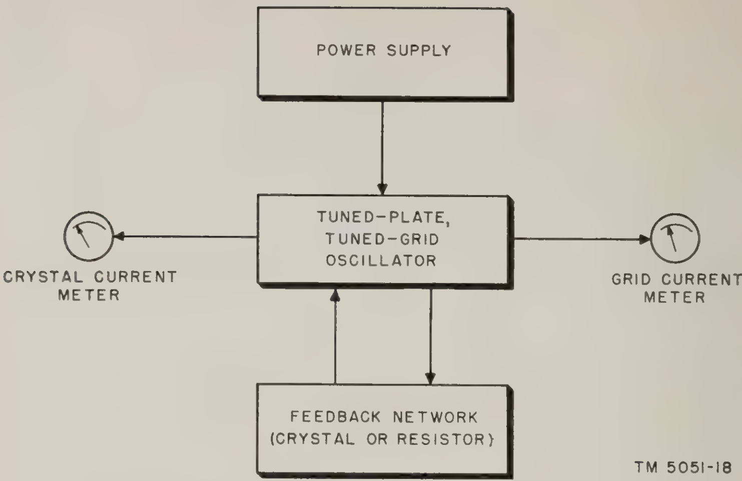


Figure 7. Crystal Impedance Meter TS–330/TSM, block diagram.

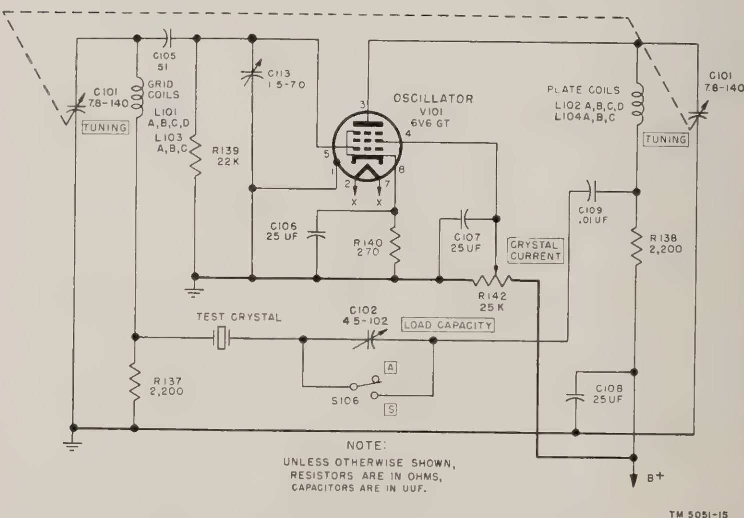


Figure 8. Simplified over-all schematic diagram.

in series with the crystal unit, then at a correct operating frequency, the combination of the crystal unit and load capacitance appears as a pure resistance. Therefore, in either case, a resistance may be substituted for the crystal unit or for the combination of crystal unit and load capacitance; this resistance can be adjusted to such a value that the oscillation frequency and amplitude are the same as they

were before the substitution was made. This value of resistance is, therefore, the effective series resonant resistance (R), or the effective antiresonant resistance (R_e), as the case may be.

(3) In actual use, neither the series resonant nor antiresonant frequency may be known; this information, however, is not necessary. The circuit of the crystal impedance meter (connected to appropriate frequency measuring equipment, figure 6) is tuned first to the approximate frequency; then, by alternate adjustment of the value of the substitution resistance and of the circuit tuning, the correct frequency and value of resistance are obtained. Generally, adjustment must be made only two or three times before complete satisfaction of the boundary conditions is attained. These adjustments may be compared with the resistance and reactance adjustments performed in balancing and impedance bridge.

b. Power Supply.

(1) The power supply (fig. 9) is a conventional type that converts 115 volts ac, 50 to 1,720 cps, to the regulated voltage necessary for the plate and screen grid of oscillator tube V101. The power supply uses rectifier tube 5Y3GT in a full-wave rectifier circuit and two tubes OC3W as voltage regulators. The tubes are shown as V102, V103, and V104. Fuse F101 rated at 1 ampere, 250 volts, opens the line if an overload or short inside the CI meter occurs. Power ON–OFF switch S108 breaks one side of the a-c line.

(2) Transformer T101 has a primary rating of 115 volts ac, single-phase, with output windings on the secondary of 700 volts at 35 ma (milliamperes) center-tapped for the plates of V102, 5.0 volts at 3.0 amperes for the filament of V102, and 6.3 volts at 2.5 amperes for the filament of V101 (oscillator tube 6V6GT) and pilot lamp E101. The rectified voltage is taken off one side of the filament of tube V102 rectifier.

(3) The rectified output of V102 is filtered free of ripples by resistors R143 and R144 and capacitors C111A and C111B (two sections). The filter is connected to a voltage dropping resistor R145 which, in turn, is connected to the voltage regulating tube V103. The tube V103, operating in conjunction with resistor R145, maintains the voltage across its terminals constant approximately at 105 volts, despite normal changes in line voltage and current drain of the connected circuits. Should the voltage across this gaseous regulator rise, the tube would draw more current; this causes a greater voltage drop across R145 and keeps the voltage at the plate (pin 5) of V103 constant. Should the line voltage drop because of outside causes, less current will be drawn by

tube V103, the voltage across R145 will be smaller, and the voltage at the plate (pin 5) of tube V103 will be kept constant.

(4) Voltage regulators V103 and V104 are connected in series to maintain a sufficiently high d-c voltage for the plate of the oscillator tube V101. The screen grid of tube V101 is supplied with d-c voltage controlled by potentiometer R142 (CRYSTAL CURRENT control) connected across the voltage regulator tube V104. This screen grid voltage controls the amplitude of oscillations. Pilot lamp E101 is operated from the 6.3-volt winding of the secondary of transformer T101. The .003-μf (microfarad) capacitor C112 bypasses r-f current from the input a-c power line to ground. The .25-μf capacitor C108 prevents r-f currents of the plate circuit from flowing in the power supply circuit.

c. Oscillator Circuit.

(1) The oscillator circuit has a beam power tube V101, 6V6GT, operating as a class *C* amplifier. The feedback paths provided by either the crystal or the decade resistor cause the circuit to operate as a class *C* oscillator. The frequency bands (seven) are selected with the two-section switch S105 by switching the r-f coils L102A, B, and C and L104A, B, and C into the plate circuit, and the corresponding r-f coils L101A, B, C, and D and L103A, B, and C into the grid circuit of tube V101. The frequency range is from 1 to 15 mc. Each band is tuned with a variable dual section (split stator) capacitor C101, TUNING control. Jack J105 (fig. 11) is connected to the plate circuit by means of a capacitive

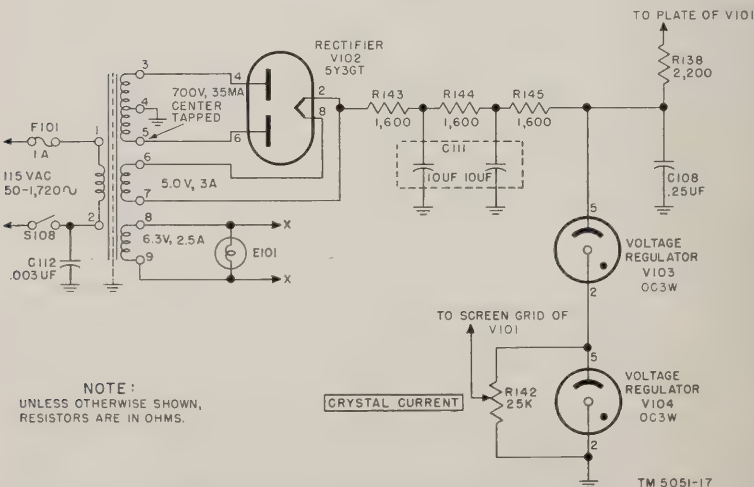


Figure 9. Power supply, schematic diagram.

coupling which consists of a minimum of 2½ turns of insulated wire wound around the plate lead.

(2) When the control grid (pin 5) is driven positive during a cycle of oscillation, a rectified current flows through the

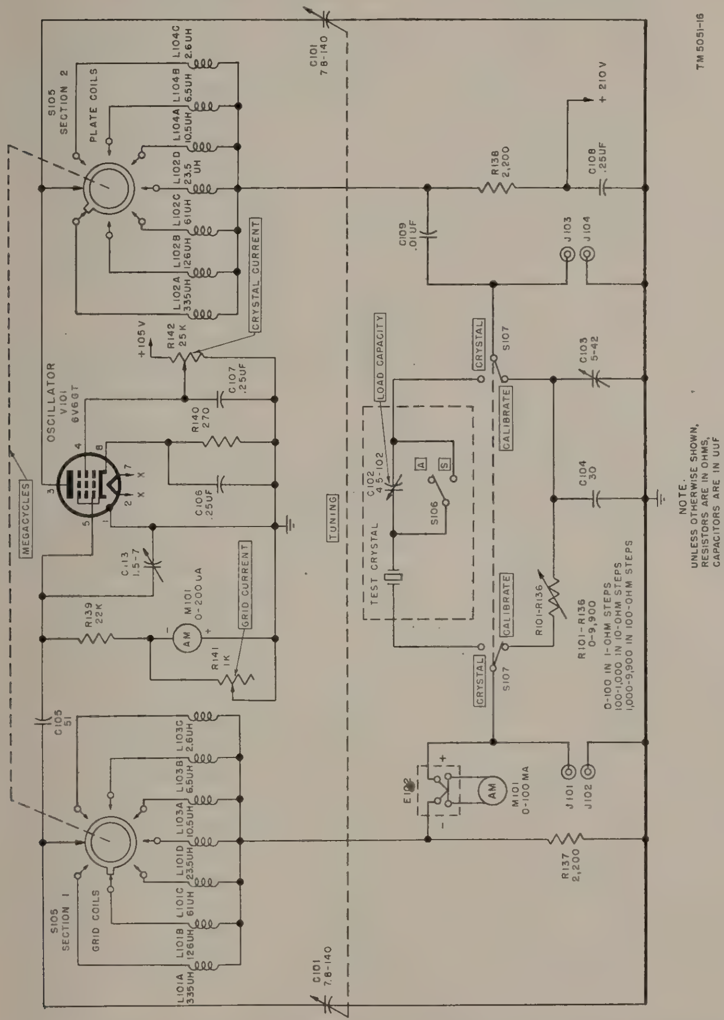


Figure 10. Feedback and oscillator circuits.

22,000-ohm grid leak resistor R139, the GRID CURRENT meter M101 (the sensitivity of which is adjusted by potentiometer R141 (GRID CURRENT control)) to ground. Capacitor C105 blocks the rectified control grid current from flowing through the grid tank circuit which consists of r-f

coils L101A, B, C, and D and L103A, B, and C and one section of capacitor (variable) C101. The screen grid positive d-c voltage obtained from the potentiometer R142 (CRYSTAL CURRENT control), connected across the voltage regulator tube V104, controls the amplitude of oscillation. Capacitor C107 bypasses r-f from screen grid to ground. The cathode (pin 8) is connected to the cathode bias resistor R140 in parallel with bias capacitor C106. Variable capacitor C113 is connected between control grid and ground to compensate for the effect of stray wiring and interelectrode capacitance.

d. Feedback Network. The feedback path (figs. 8 and 10) has two sections—the crystal socket assembly and the resistance substitution decade. Lever switch S107 (CALIBRATE-CRYSTAL) connects either one section or the other into the feedback path. The .01-μf capacitor C109 provides a low-impedance path for the r-f voltage developed across resistor R138 by the r-f current generated in the tuned-plate tank circuit of tube V101. Capacitor C109 also provides the necessary phase relation for the r-f voltage feedback to the grid circuit. The feedback voltage is injected into the grid circuit across the voltage dividing resistor R137. Switch S106 (S-A) is mounted in the crystal socket assembly and short-circuits the 4.5- to 102-$\mu\mu$f variable capacitor C102 (LOAD CAPACITOR) for series-resonant tests on crystals. Inductance L105 (1 to 4 turns of air-core, self-supporting wire) adjusts the frequency of oscillation in the CRYSTAL position of S107 to be the same as that in the CALIBRATE position (par. 42). The resistance substitution network consists of resistors R101 through R136 with decade resistor switches S101 and S102 and toggle switches S103 and S104 to select the substitution resistance from 0 to 9,900 ohms. The resistance decades are switched into the oscillator circuit and adjusted to obtain the same amplitude of oscillation as the oscillating crystal unit. The switch positions of the decades then indicate the resistance. The crystal current is measured with meter M102 and thermocouple E102. The fixed 30-$\mu\mu$f capacitor C104 and the variable 5- to 42-$\mu\mu$f capacitor C103 are connected between the resistance decades and ground, and compensate for the capacitance of the crystal socket assembly to ground. The crystal socket assembly and the box shield around it are insulated from ground. The crystal socket assembly will accommodate any two-pin crystal unit with a center-to-center pin spacing of .5 to 1.25 inches; crystal holders similar to crystal holder FT-249 may be tested. The crystal socket assembly adds a minimum of capacitance across the crystal.

Section II. PREREPAIR PROCEDURES

Note. This section contains information for field maintenance. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available and by the skill of the repairman.

28. Tools, Materials, and Test Equipment

Tools, materials, and test equipment needed for performing the prerepair procedures in this section are listed below:

- Common hand tools.
- Tube Puller TS–201.
- Vacuum-tube voltmeter, such as Electronic Multimeter TS-505/U.
- Multimeter TS–352/U.
- Tube Tester I–177, I–177–A, or I–177–B.

29. Removal of Pluck-Out Parts

a. Tubes.

(1) Remove the cover from the equipment by removing the No. 6–32 screws around the top, sides, and back.

(2) Use Tube Puller TS–201 to remove the tubes (fig. 11) from their sockets. If the space around the tube is so limited that the tube puller cannot be used, the tube will have to be pulled out with the fingers; however, first be sure the tubes have cooled sufficiently. Do not rock the tube or jiggle it in its socket if it can be extracted by a direct upward pull. Rock it *gently* if it does not release easily. Jiggling a tube in its socket during removal spreads the contacts. Label each tube as soon as it is removed so that it can be replaced later in its proper socket.

b. Fuse. Remove fuse F101 by turning fuseholder E103 on the back of the chassis (fig. 11) counterclockwise. Pull the cartridge fuse out of the cover.

c. Lamp. Unscrew the jewel guard of the light indicator (I–101) on the front panel (fig. 3), and remove the bayonet-base lamp (E101) by pushing it in and turning it clockwise.

30. Cleaning, Inspecting, and Testing Pluck-Out Parts

a. Cleaning, Inspecting, and Testing Tubes.

(1) *Cleaning.* Clean the tubes with a cloth moistened with solvent (SD). If necessary, clean prongs with crocus cloth.

(2) *Inspecting.* Inspect the tubes for cracks in glass and base and for bent and broken prongs.

(3) *Testing.* Test the tubes for proper emission, leakage, and short circuits. Use Tube Tester I–177, I–177–A, or I–177–B, or place doubtful tubes in a unit known to be operating normally.

b. CLEANING, INSPECTING, AND TESTING FUSE.

(1) *Cleaning.* Clean fuse ends with emergy cloth and wipe with a clean cloth. If a file is used to remove deep pits, use crocus cloth to leave a smooth contact surface and then wipe dry with a clean cloth.

(2) *Inspecting.* Inspect fuse ends for evidence of burning, corrosion, and looseness.

(3) *Testing.* Check fuse for continuity.

c. INSPECTING PILOT LAMP. Inspect the lamp for continuity of filament. Be sure that the lamp base is not loose.

31. Cleaning and Inspecting Chassis Assembly

a. CLEANING. Thorough cleaning of the CI meter is necessary to insure optimum performance by preventing corrosion, rust, and dust from damaging parts or causing arc-over or low-resistance leakage between high-voltage points and ground. Remove loose dust and dirt with a brush or blower. Use a brush or cloth with solvent (SD) to remove dirt and grease which adheres to the chassis (fig. 12) and parts.

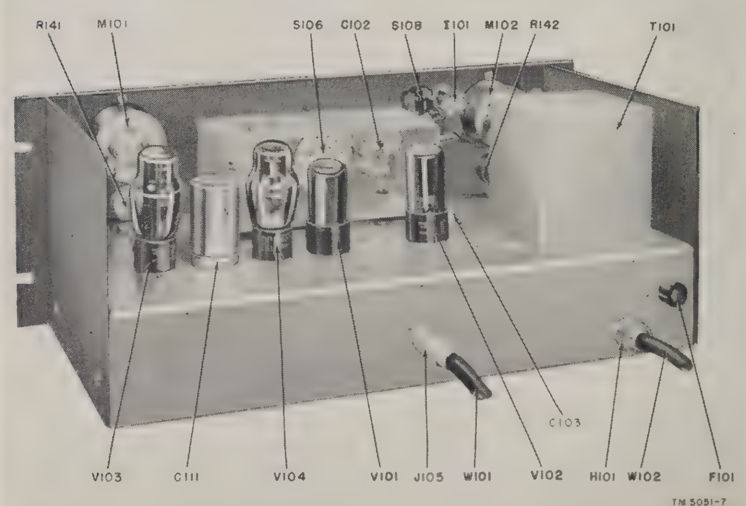


Figure 11. Panel and chassis assembly, rear view.

DEPARTMENT OF THE ARMY TECHNICAL MANUAL
AND DEPARTMENT OF THE AIR FORCE TECHNICAL ORDER

CRYSTAL IMPEDANCE METER TS-330/TSM

C1, TM 11-5051
TO 16-35TS-330-5

DEPARTMENTS OF THE ARMY AND THE AIR FORCE
WASHINGTON 25, D. C., *30 April 1954*

TM 11-5051/TO 16-35TS-330-5, 4 April 1951, is changed as follows:

CHAPTER 1
INTRODUCTION

Note. (Added) Crystal Impedance Meter TS-330/TMS, procured on Order No. 6883-Phila-51, is similar to Crystal Impedance Meter TS-330/TSM covered in TM 11-5051 to 16-35TS-330-5. Information in this manual which applies to the TS-330/TSM applies equally to the TS-330/TSM (6883-Phila-51) unless stated otherwise in this change.

5. Description

*   *   *   *   *   *   *

b. Crystal Impedance Meter TS-330/TSM. This meter (fig. 3) * * * for rack mounting. **The TS-330/TSM (6883-Phila-51) is inclosed in a light gray metal case.** The overall dimensions * * * (cycles per second). Furnished with the meter are a 6-foot **or 5-foot (TS-330/TSM (6883-Phila-51))** r-f (radio-frequency) pick-up cable assembly with plug attached and a load capacitance calibration chart (par. 13). The CI meter is portable; for carrying purposes, it is placed inside Case CY-23/TSM (which is part of Crystal Test Set AN/TSM-3 (*a* above)).

10. Preparation for Use

Place the equipment on a bench or in a standard relay rack, and proceed as follows:

*   *   *   *   *   *   *

d. Place the tubes into their respective sockets.

Note. (Added) Tube retainers secure the tubes in the TS-330/TSM (6883-Phila-51). Before placing the tubes into their sockets, loosen and remove the tube retainer nuts. Insert the tubes into their respective sockets. Slide the tube retainers over the tubes (fig. 11.1) and tighten the tube retainer nuts.

*   *   *   *   *   *   *

23. Standard Frequency Test Rack

Frequency Calibrator Set AN/URM–18 (fig. 6.1) is used to determine the frequency of the voltage being applied to the crystal under test by the TS–537/TSM. The AN/URM–18 consists of the following components:

a. Frequency Calibrator FR–46/URM–18
b. Multivibrator Power Supply 0–122/URM–18
c. Frequency Meter FR–43/URM–18
d. Frequency Meter FR–44/URM–18
e. Frequency Meter FR–45/URM–18
f. Signal Generator SG–42/URM–18
g. Oscilloscope OS–16/URM–18
h. Control Panel SB–105/URM–18
i Magnetic Loudspeaker LS–205/U
j. Rack MT–746/U
k. Rack MT–747/U

Note. The crystal frequency measuring procedure outlined in paragraph 25 is a sample procedure. For a complete discussion on the use of the frequency calibrator meter set, refer to the applicable publication. Only those components used in the frequency measuring procedure in paragraph 25 are discussed.

24. Alternate Equipment
(Superseded)

Alternate frequency measuring equipment described below may be used in place of the equipment listed in paragraph 23.

a. A calibrated radio receiver may be used. The degree of accuracy will be low, however, because of the relatively poor frequency control commonly found in radio oscillator circuits.

b. Frequency Meter Set SCR–211, covering a calibrated range from 125 kc to 20 mc may be used in an emergency to provide the frequency standard in place of the multivibrator unit or interpolation oscillator (Signal Generator SG–42/URM–18). The SCR–211 may be used directly for measurement of crystal frequencies between 10 and 20 mc. Frequency Meter TS–174/U, covering a calibrated range from 20 to 280 mc, may be used directly for measurement of crystals with frequencies between 20 and 140 mc.

25. Crystal Frequency Measurements
(Superseded)

a. Preliminary Procedures. Crystal frequencies are measured under series-resonant or antiresonant conditions. The frequency measuring procedures are the same. However, the CI meter ad-

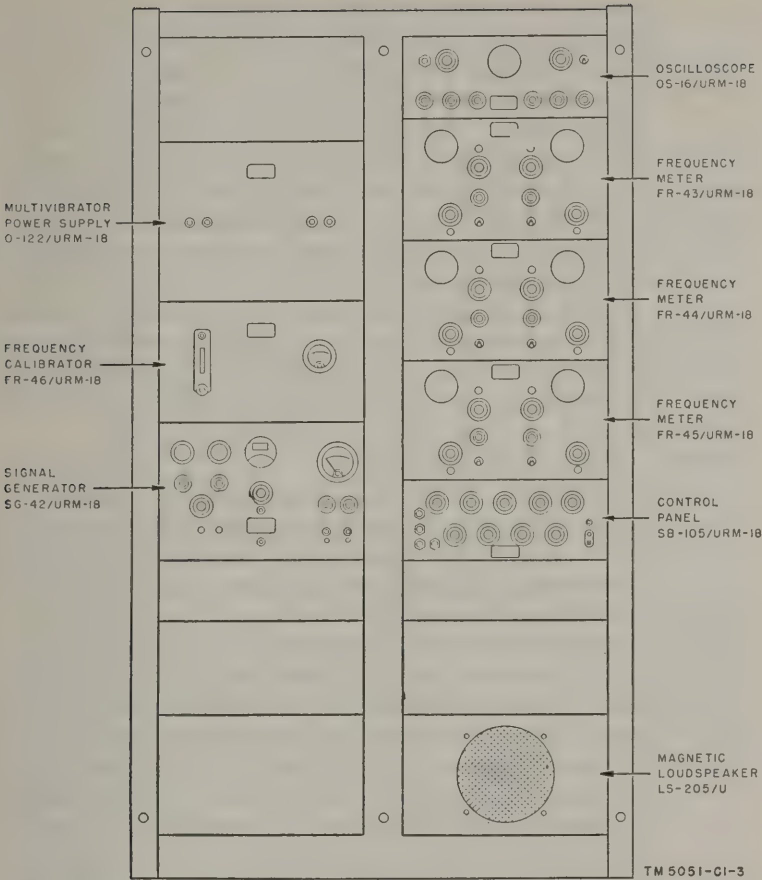


Figure 6.1. (Added) *Frequency Calibrator Set AN/NRM–18.*

justments are different for the two conditions. Determination of the frequency of a crystal is outlined in (1) and (2) below. Apply power to the required components of the AN/URM–18, and after a 15-minute warm-up period, proceed as follows:

(1) Insert the crystal in the appropriate frequency crystal jack on the panel of the CI meter, and couple the CI meter output (r-f) cable into the f_x jack on the front or the rear of Control Panel SB–105/URM–18 (fig. 6.1). Switches, coaxial jacks, patch cords, or any other method of making the interunit connections may be used; this depends on, for example, the permanency of the installation and available material. Long connections, whether

cable or open wire, should be avoided because of possible losses, pick-up, and radiation. Adjust the CI meter for series-resonant (par 12*a*) or antiresonant (par. 12*b*) operation. Operate the f_x switch to ON. Operate the FREQUENCY METER knob on the control panel to the M or H position (for Frequency Meter FR–44/URM–18 or FR–45/URM–18). Operate the DETECTOR-INTERPOLCATOR switch to the TEL or SPKR position (depending on which hearing device is being used for aural detection) on the DETECTOR side of the switch.

(2) Rotate the detector RANGE switch to select the desired frequency range. Adjust the f_x volume control, the detector tuning control, and the REGENERATION control to obtain the required signal at its fundamental frequency.

b. Use of Frequency Meter.

(1) The effective operation of a regenerative detector requires a certain amount of practice. The beginning of oscillations usually occurs when the REGENERATION control has been advanced about one-quarter to one-half from the minimum position. For any given frequency setting, the most sensitive condition for receiving continuous wave signals is just *after* oscillations have started. The most sensitive condition for modulated signals is just *below* the point at which oscillations start. It is therefore extremely important that the REGENERATION control be carefully adjusted. If the control is advanced too far, the detector may be blocked, and a squeal will be heard in the output.

Caution: Do not apply too strong a signal to the detector; this may cause overloading. Detector sensitivity is highest at fairly low signal strength. When trying to obtain beats between two signals, adjust them individually to about the same level. If continuous-wave signals are being received, too strong a signal may lock the detector into synchronization over an appreciable range on the frequency dial.

(2) If difficulty is encountered in picking up a signal whose frequency is unknown, introduce a standard harmonic frequency signal by operating the STANDARD FREQUENCY HARMONICS switch to the 100-kc or 10-kc position, and advancing the corresponding volume control. Adjust the detector to obtain a sensitive oscillating condition on any of the standard frequency signals. After

the detector has been adjusted, operate the STANDARD FREQUENCY HARMONICS switch to the OFF position, and proceed to search the resultant small range for the desired signal. Use a preadjusted detector for this purpose.

(3) If the frequency to be measured is higher than 20 mc, it may be difficult to obtain the beat frequency difference directly against the standard; the harmonics of the standard being used are so close together that considerable care must be exercised to identify the harmonic used in the measurement. Coincidental with their closeness, such high order harmonics become weaker and weaker as the frequency is raised until a point is reached where satisfactory beats between the standard frequency harmonic and the unknown frequency can no longer be obtained.

(4) When attempting to measure a high frequency in a range where a satisfactory beat cannot be obtained, set the frequency meter (the FR–45/URW–18, or the meter covering the next lower range, the FR–44/URM–18) to a known fraction of the frequency being measured. This can be accomplished because the approximate value frequency measurement is known immediately from the calibration of the detector unit. Measure the fundamental frequency of the frequency meter being used, and multiply the result by the number of harmonics to obtain the value of the unknown frequency. When performing the above operations, the M–H position of the FREQUENCY METER switch can be used to great advantage.

c. Deriving Audio Beat Difference Between Transferred and Standard Frequencies. After the frequency to be measured has been picked up and identified in the detector unit of the frequency meter (detector usually in oscillating condition), introduce the standard frequency harmonics into the detector as outlined below.

(1) Operate the STANDARD FREQUENCY HARMONICS switch on the control panel to the 10-kc position and adjust the corresponding volume control.

(2) Retard the REGENERATION control slightly, until oscillation stops, in order to reduce the amount of regeneration in the detector. A single clear tone now should be heard from the headset or speaker.

(3) Vary the adjustments of the f_x and the 10-kc volume control to obtain the best beat frequency signal. If a high frequency is being measured, try the 100-10-kc position

on the selector switch, adjusting the 100- and 10-kc volume controls to obtain the best results.

(4) Critical regeneration is not needed when using the detector in the nonoscillating condition (if the signal levels are high enough). The r-f signal levels can be adjusted to higher values, resulting in greater beat frequency output. Do not, however, adjust the signal level for more than a comfortable headset signal.

(5) When weak signals are received, advance the REGENERATION control on the control panel to the point where oscillation almost begins. In this case, the regeneration and detector controls must be tuned carefully to obtain the best beat frequency output.

d. Determining Sign of Beat Frequency Difference.

(1) If the sign of the beat frequency difference is not known (if the sign is above or below the standard beat frequency harmonic), the location of the unknown frequency relative to the standard harmonic frequency can be determined from the detector tuning adjustment. Using the detector in the oscillating condition, obtain the zero beat against the frequency being measured.

(2) Operate the f_x switch to the OFF position and set the STANDARD FREQUENCY HARMONICS selector switch on the 10-kc position. A beat note will result. *Carefully advance* (clockwise) the detector tuning control; if the beat note *rises*, the unknown frequency is *higher* than the standard frequency, establishing the sign of the beat frequency difference as *plus*. If the beat note *falls*, the unknown frequency is *lower* than the standard frequency and the sign of the beat frequency difference is *minus*.

e. Determining Value of Beat Frequency Difference.

(1) The beat frequency difference is applied automatically to the input terminal on Signal Generator SG–42/URM–18 (interpolation oscillator). Operate the DETECTOR-INTERPOLATOR switch to the TEL or SPKR position on the interpolator side of the switch and listen to the match between the interpolation oscillator and the beat frequency. Adjust the INPUT (beat frequency) and OUTPUT (oscillator) volume controls on the interpolation oscillator until equal deflection is obtained on the output meter at half-scale.

(2) If the sign of the beat frequency difference is *plus*, move the DIRECT-REVERSE (scale selector) switch

on the interpolation oscillator to the DIRECT position. Adjust the frequency of the interpolation oscillator to match the beat frequency. As the match is approached, the output meter needle will swing from nearly zero to nearly full scale. Adjust the frequency of the interpolation oscillator until the meter needle stands still, or moves very slowly. Slow oscillation of the meter needle is accompanied by a slow waxing and waning of the intensity of the note heard in the speaker or phones (connected directly to the interpolation oscillator). The direct scale on the interpolation oscillator now indicates the value of the beat frequency in cycles per second.

27. Functioning of Crystal Impedance Meter TS–330/TSM

*   *   *   *   *   *   *

c. Oscillator Circuit.

(1) The oscillator circuit * * * class C oscillator. The frequency bands (seven) are selected with the two-section switch S105 by switching the r-f coils L102A, B, C, **and D,** and L104A, B, and C into the plate circuit, and the corresponding r-f coils L101A, B, C, and D and L103A, B, and C into the grid circuit of tube V101. The frequency range * * * C101, TUNING control. Jack J105 (fig. 11 **or 11.1**) is connected to the plate circuit by means of a capacitive coupling which consists of a minimum of 2½ turns of insulated wire wound around the plate lead.

*   *   *   *   *   *   *

Figure 10. The designation M101 0–100 MA is changed to read: **M102 0–100 MA.**

29. Removal of Pluck-Out Parts

a. Tubes.

*   *   *   *   *   *   *

(1.1) (Added) On Crystal Impedance Meter TS–330/TSM–(6883–P–51) only, remove the tube retainers by loosening and removing the tube retainer nuts (fig. 11.1).

(2) Use Tube Puller TS–201 to remove the tubes (fig. 11 **or 11.1**) from their sockets. If the space * * * its proper socket.

b. Fuse. Remove fuse F101 by turning fuseholder E103 on the back of the chassis (fig. 11 **or 11.1**) counterclockwise. Pull the cartridge fuse out of the cover.

*   *   *   *   *   *   *

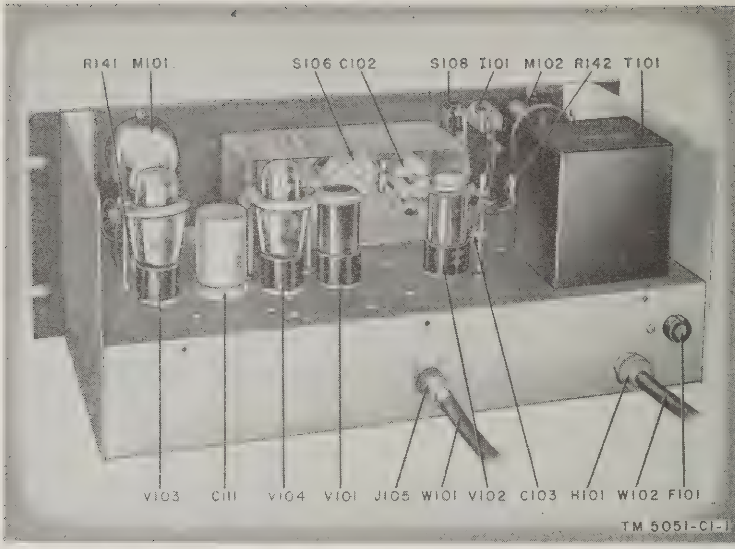


Figure 11.1. (Added) *Panel and chassis assembly, rear view, (TS–330/TSM (6883–Phila–51)).*

32. Reassembling Crystal Impedance Meter

Replace the tubes, **tube retainers (TS–330/TSM (6883–Phila–51 only))** fuses, and pilot lamp in the CI meter. Be sure the tubes are put back in the correct sockets (fig. 11 **or 11.1**).

33. Troubleshooting Procedure

a. Data. Take advantage of * * * following troubleshooting data:

Fig. or par. No.	Description
* * *	* * * *
Fig. 18 **or 18.1**	Wiring diagram.

* * * * * * *

37. Localizing Troubles

Check the d-c * * * and tube V101. If voltages appear correct, refer to the wiring diagram (fig. 18 **or 18.1**), and check the crystal holder network and the decade resistor assembly for wiring continuity or shorts to chassis.

38. Replacement Procedure

* * * * * * *

d. Disassembly of Meter.

* * * * * * *

(4) Unsolder the two connecting wires (tag points) on the underside of the chassis (fig. 11 **or 11.1**).

* * * * * * *

(6) Tag and unsolder wires from the toggle switch S108, pilot lamp E101, and potentiometers R141 and R142 (fig. 11 **or 11.1**). Remove these components from the panel.

* * * * * * *

(9) The chassis, has been disassembled to the point that the various other switches, coils (**d.1 below**), resistors decades, etc., can be removed as desired without interference.

d.1 (Added) *Replacement of Coils.* Proper polarity must be observed when replacing coils. The start and finish wire ends of the replacement coil must be connected to the same wires as the start and finish ends of the original coil. If proper polarity is not observed, the equipment may oscillate (par. 45). The coil ends are identified and located as follows:

(1) The lead from the inside (bottom layer) of the coil is designated the start end.

(2) The lead from the outside (top layer) of the coil is designated the finish end.

* * * * * * *

40. Readjustment of Capacitor C103

Make this adjustment * * * on 2-inch centers.

* * * * * * *

b. Measurement of Capacity From Point Q to Ground.

* * * * * * *

(2) (Superseded) Adjust capacitor C103 (fig. 11 or 11.1) with a nonmetallic screwdriver until the measured capacity is equal to the capacity measured from P to ground (*a*(4) above).

41. Measurement and Adjustment of Frequency

Note. These adjustments have * * * has been replaced.

The overlap of the frequency ranges should be approximately as tabulated below. Measure the frequency of oscillation with Frequency Meter Set SCR–211 connected to r-f cable assembly W101 (fig. 11 **and 11.1**). The frequency overlap can be adjusted only by adding or removing turns from the tuned plate or grid inductance.

* * * * * * *

45. Oscillation Test

With CALIBRATE-CRYSTAL switch * * * extreme clockwise direction. No self-controlled oscillation should be observed either by an indication of grid current other than residual grid current, or by the presence of a signal on a communication receiver. The condition of * * * condition of oscillation.

Note. (Added) If a tuning coil has been replaced, be sure that the proper polarity exists (par. *38d.1*); oscillation may occur if the polarity coil is reversed.

BY ORDER OF THE SECRETARIES OF THE ARMY AND THE AIR FORCE:

M. B. RIDGWAY,
General, United States Army,
Chief of Staff.

OFFICIAL:
JOHN A. KLEIN,
Major General, United States Army,
Acting The Adjutant General.

N. F. TWINING,
Chief of Staff, United States Air Force.

OFFICIAL:
K. E. THIEBAUD,
Colonel, United States Air Force,
Air Adjutant General.

DISTRIBUTION:

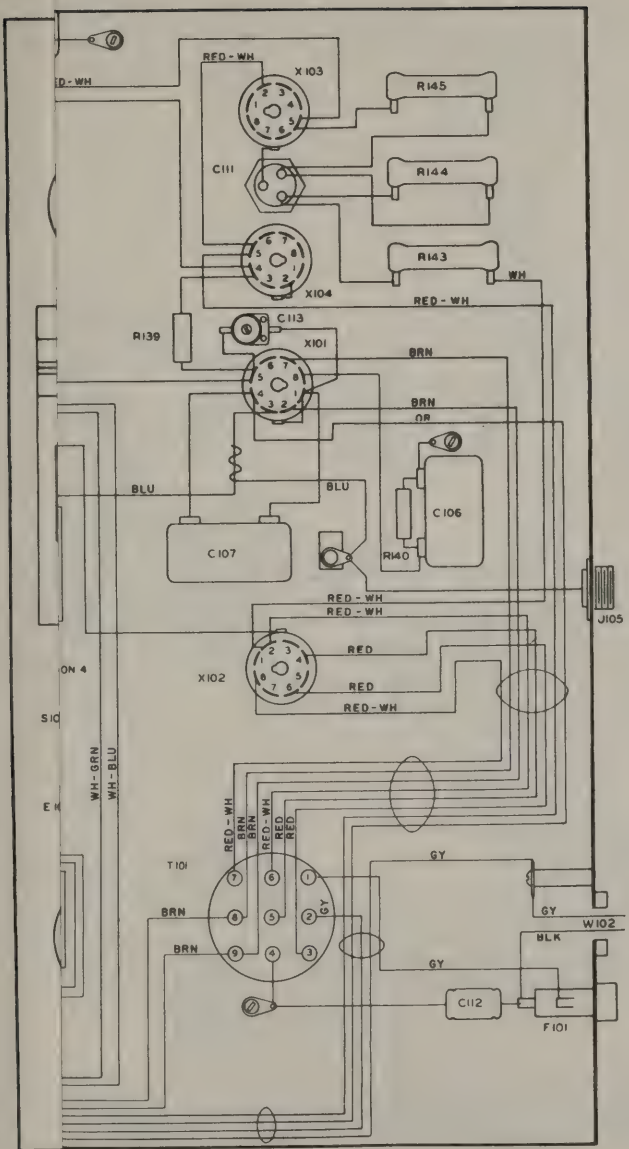
Active Army:

C/Tech Svcs, DA (1)
Tech Svc Bds (1)
C/AFF (5)
AFF Bds (incl ea Svc Test Sec) (1)
Hq, Army AA Comds (2)
Hq, OS Maj Comds (5)
Hq, OS Base Comds (5)
Hq, Log Comds (5)
Hq, MDW (2)
Hq, Armies (5)
Hq, Corps (2)
Hq, Tng Divs (2)
Hq, Forts & Camps (2)
Hq, Gen & Br Svc Schs (5)
Hq, SigC Sch (25)
Hq, Gen Depots (2)
Sig Sec, Gen Depots (10)
Hq, Sig Depots (20)
Hq, POEs (2)
C/OS Sup Agencies (2)
SigC Labs (5)
SigC Fld Maint Shops (3)

NG: Same as Active Army except allowance is one copy for each unit.

USAR: None.

Unless otherwise noted, distribution applies to CONUS and overseas.


RED-WH
X103
R145
C111
R144
R143
WH
X104
RED-WH
C113
R139
X101
BRN
BRN
OR
BLU
BLU
C106
C107
R140
RED-WH
RED-WH
J105
X102
RED
RED
RED-WH
ON 4
WH-GRN
WH-BLU
RED-WH
BRN
BRN
RED-WH
RED
RED
T101
GY
GY
BRN
BRN
GY
W102
BLK
GY
C112
F101

TM 5051-C1-2

45. Oscillation Test

With CALIBRATE-CRYSTAL switch * * * extreme clockwise direction. No self-controlled oscillation should be observed either by an indication of grid current other than residual grid current, or by the presence of a signal on a communication receiver. The condition of * * * condition of oscillation.

Note. (Added) If a tuning coil has been replaced, be sure that the proper polarity exists (par. *38d.1*); oscillation may occur if the polarity coil is reversed.

BY ORDER OF THE SECRETARIES OF THE ARMY AND THE AIR FORCE:

M. B. RIDGWAY,
General, United States Army,
Chief of Staff.

OFFICIAL:
JOHN A. KLEIN,
Major General, United States Army,
Acting The Adjutant General.

N. F. TWINING,
Chief of Staff, United States Air Force.

OFFICIAL:
K. E. THIEBAUD,
Colonel, United States Air Force,
Air Adjutant General.

DISTRIBUTION:

Active Army:

C/Tech Svcs, DA (1)
Tech Svc Bds (1)
C/AFF (5)
AFF Bds (incl ea Svc Test Sec) (1)
Hq, Army AA Comds (2)
Hq, OS Maj Comds (5)
Hq, OS Base Comds (5)
Hq, Log Comds (5)
Hq, MDW (2)
Hq, Armies (5)
Hq, Corps (2)
Hq, Tng Divs (2)
Hq, Forts & Camps (2)
Hq, Gen & Br Svc Schs (5)
Hq, SigC Sch (25)
Hq, Gen Depots (2)
Sig Sec, Gen Depots (10)
Hq, Sig Depots (20)
Hq, POEs (2)
C/OS Sup Agencies (2)
SigC Labs (5)
SigC Fld Maint Shops (3)

NG: Same as Active Army except allowance is one copy for each unit.

USAR: None.

Unless otherwise noted, distribution applies to CONUS and overseas.

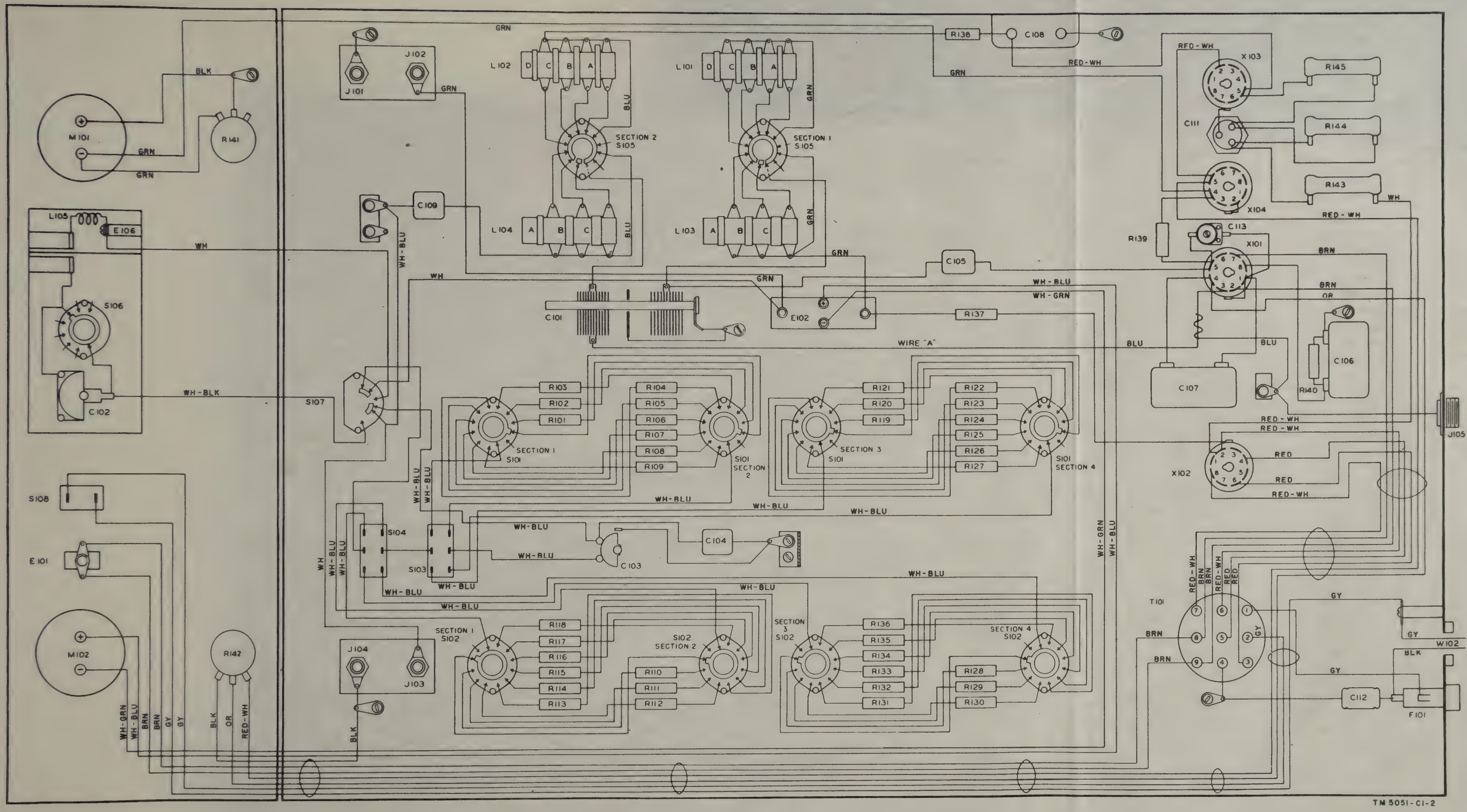


Figure 18.1 Wiring Diagram for Crystal Impedance Meter TS–330/TSM (6883–Phila–51).

DEPARTMENT OF THE ARMY TECHNICAL MANUAL AND
DEPARTMENT OF THE AIR FORCE TECHNICAL ORDER

CRYSTAL IMPEDANCE METER

TS-330/TSM

C2, TM 11-5051
TO 16-35TS-330-5
CHANGES No. 2

DEPARTMENTS OF THE ARMY AND
THE AIR FORCE
WASHINGTON 25, D. C., *9 November 1954*

TM 11-5051/TO 16-35TS-330-5, 4 April 1951, is changed as follows:

40. Readjustment of Capacitor C103

Make this adjustment * * * on 2-inch centers.

a. Measurement of Capacity From Point P to Ground. Place the CALIBRATE-CRYSTAL switch S107 in the CALIBRATE position and proceed as follows:

* * * * * * *

(5) (Added) During this test the top cover must remain in place.

b. Measurement of Capacity from Point Q to Ground.

* * * * * * *

(2) Adjust capacitor C103 * * * ground (*a*(4) above). **The top cover may be removed for this adjustment.**

42. Frequency Correlation Between CRYSTAL and CALIBRATE Positions

(Superseded)

Check the frequency correlation between CRYSTAL and CALIBRATE positions (fig. 3) as follows:

a. Under operating conditions, set MEGACYCLES switch S105 to 10.00-15.00 position.

b. Set switches S102 to 1, S104 to X10, and S103 to X100.

c. Insert a 10-ohm, ½-watt, composition resistor in the crystal socket.

d. Set switch S107 to the CALIBRATE position.

e. Rotate the LOAD CAPACITY dial to 0.

f. Rotate GRID CURRENT meter sensitivity control R141 to maximum. Increase CRYSTAL CURRENT control R142 until the meter reads 150 microampere (μa).

g. Adjust the TUNING capacitor dial to obtain 12.5 mc. Measure this frequency with Radio Receiver BC-348-M, or Radio Receiver BC-342 if the BC-348-M is not available. Zero-beat the signal with the receiver bfo (fig. 6).

h. Set switch S107 to the CRYSTAL position.

i. Set switch S106 to the S position.

j. Note the receiver audio-output frequency (par. 24). The difference in frequency caused by moving S107 from CRYSTAL to CALIBRATE should be less than 1,000 cps. If the difference is greater than 1,000 cps, extend the length of coil L105 (fig. 19) until the frequencies at CRYSTAL and CALIBRATE positions are approximately equal. Coil L105 is one-half inch in diameter and consists of 1 to 4 turns of #16 AWG gate tinned copper wire. It is in series between one crystal unit socket terminal and the lead that enters the shield assembly on the grid side. *L105 is present only in CI meters that require it.* Adjust L105 only after adjusting C113 (par. 43*l*).

43. Performance Test

(Superseded)

Note. These adjustments have been made during manufacture. Do not repeat these adjustments unless an oscillator coil has been replaced.

Test the performance of the CI meter for each position of MEGACYCLES switch S105 as follows:

a. With switch S107 in the CALIBRATE position, measure the capacitance from point P to ground with Q Meter TS–617/U in conjunction with precision capacitor (SigC Stock No. 3F2470), or equal (par. 40).

b. Set switch S107 to the CRYSTAL position and vary C103 until the measured capacitance from point Q to ground is equal to the capacitance from point P to ground.

Note: It is not necessary to repeat the procedure of *a* and *b* above for successive band switch positions.

c. Set switch S107 to the CALIBRATE position.

d. Set the decade resistors successively to the values listed in the chart below for the band being tested.

Table of decade resistor values

Range (mc)	Resistance value (ohms)	Frequency (mc)
1.00–1.50	1,000	1.30
1.50–2.25	500	2.00
2.25–3.40	220	3.00
3.40–5.10	120	4.00
5.10–7.50	55	6.00
7.50–10.00	25	8.50
10.00–15.00	15	12.00

e. Insert a resistor of the same value as that in *d* above into the crystal socket. This resistor must be of the composition type with leads as short as possible. The rf resistance of the resistor should be

within ±1 percent of the desired value as measured on impedance bridge (SigC stock No. 3F2009).

f. When the decade resistors are set for 500 ohms, set switch S104 to X10. When the decade resistor is set for 1,000 ohms, set S103 to X1.

g. Adjust the TUNING dial to obtain the corresponding frequency listed.

h. Rotate the GRID CURRENT control in a clockwise direction until all the resistance is in the meter shunt circuit.

i. Adjust CRYSTAL CURRENT control R142 until 150 μa or an approximate convenient value of rectified GRID CURRENT is indicated.

j. Set switch S107 to CRYSTAL.

k. Set switch S106 to S and rotate LOAD CAPACITY dial to minimum (fig. 3).

l. The GRID CURRENT meter indication must not vary more than ±3 percent or 4.5 μa from the 150-μa point. There are two solder dots on capacitor C113: one on the stationary disk and one on the movable disk. Turn the disk until these dots are on opposite sides. Capacitor C113 is now at its minimum value. Slowly increase the capacitance until the change of GRID CURRENT meter reading between CALIBRATE and CRYSTAL positions of switch S107 is at a minimum. Adjust C113 prior to adjusting L105. (Refer to the note at the beginning of this paragraph.)

m. Usually, setting capacitor C113 at one-third of its maximum value is satisfactory for all units. This setting is made before performance tests are started.

44. Checking Load Capacitance Chart

The load capacitance chart is prepared from data obtained by measuring the actual capacitance value (within ±1$\mu\mu$f) of capacitor C102 (LOAD CAPACITY, figs. 3 and 11) in the circuit with shorting switch C106 in the A position. **In the range of 0 to 30 on the dial, the total error should not exceed ±.2$\mu\mu$f. In the range of 30 to 100 on the dial, the total error should not exceed ±.5$\mu\mu$f.** Plotting points are * * * in figure 4.

[AG 413.6 (19 Oct 54)]

BY ORDER OF THE SECRETARIES OF THE ARMY AND THE AIR FORCE:

M. B. RIDGWAY,
General, United States Army,
Chief of Staff.

OFFICIAL:
JOHN A. KLEIN,
Major General, United States Army,
The Adjutant General.

N. F. TWINING,
Chief of Staff, United States Air Force.

OFFICIAL:
E. E. TORO,
Colonel, United States Air Force,
Air Adjutant General.

DISTRIBUTION:

Active Army:

Tec Svc, DA (1)
Tec Svc Bd (1)
AFF (5)
AFF Bd (incl ea Test Sec) (1)
Army AA Comd (2)
OS Maj Comd (5)
OS Base Comd (5)
Log Comd (5)
MDW (1)
Armies (5)
Corps (2)
Tng Div (2)
Ft & Cp (2)
Gen & Br Svc Sch (5)
SigC Sch (25)
Gen Depots (2)
SigC Sec. Gen Depots (10)
SigC Depots (20)
POE (2)
OS Sup Agencies (2)
SigC Fld Maint Shops (3)
SigC Lab (5)
Mil Dist (1)
Units organized under following TOE's:
- 11–127, Sig Rep Co (2)
- 11–128A, Sig Depot Co (2)
- 11–500A (AA through AE), Sig Admin Teams (2)
- 11–587A, Sig Base Maint Co (2)
- 11–592A, Hq & Hq Co, Sig Base Depot (2)
- 11–597A, Sig Base Depot Co (2)

NG: Same as Active Army except allowance is one copy for each unit.
USAR: None.
Unless otherwise noted, distribution applies to ConUS and overseas.
For explanation of abbreviations used, see SR 320–50–1.

U. S. GOVERNMENT PRINTING OFFICE: 1954

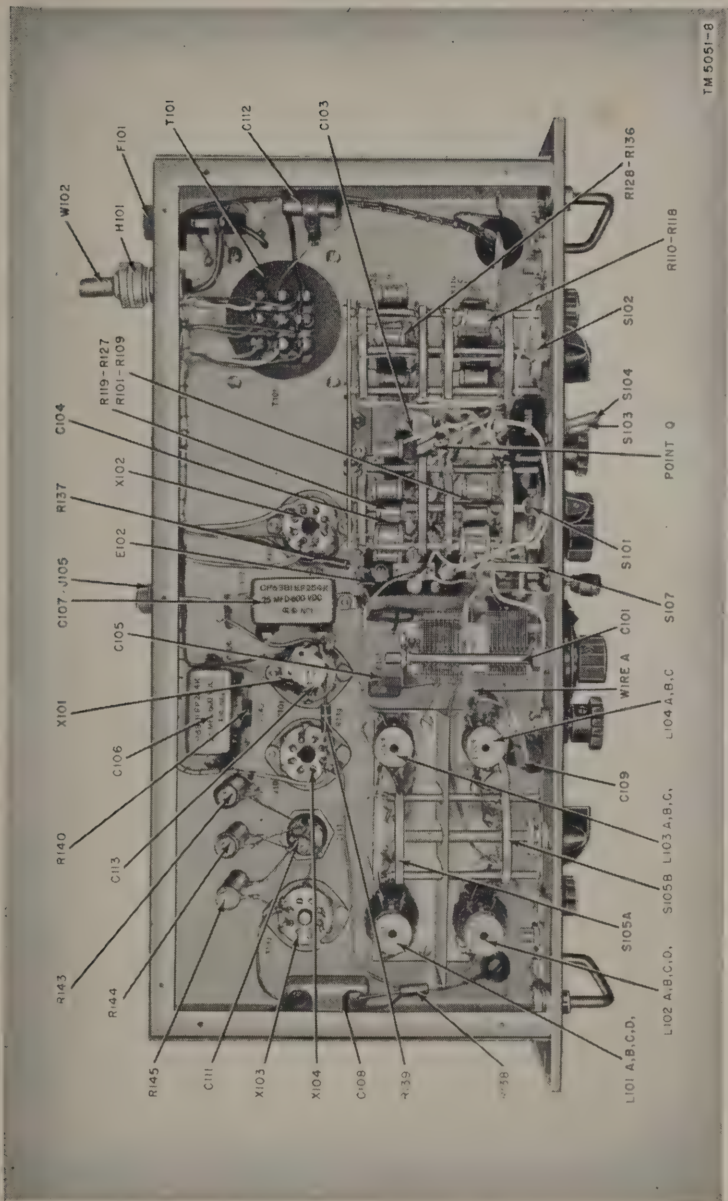


Figure 12. Chassis assembly, bottom view.

b. Inspecting. After a meter has been cleaned thoroughly and carefully, make a visual inspection of parts and wiring for rust, corrosion, loose connections, frayed and burned insulation, loose screws, burned and charred resistors and coils. Carefully inspect tube sockets for broken contacts and broken insulation, and terminal boards for broken lugs and signs of burning. Inspect and tighten all loose set screws.

32. Reassembling Crystal Impedance Meter

Replace the tubes, fuses, and pilot lamp in the CI meter. Be sure the tubes are put back in the correct sockets (fig. 11).

Section III. TROUBLE SHOOTING

33. Trouble-Shooting Procedure

a. Data. Take advantage of the material supplied in this manual. It will help in the rapid location of faults. Refer to the following trouble-shooting data:

Fig. or par. No.	Description
Par. 36*b*	Trouble location chart.
Par. 36*c*	Resistance chart.
Fig. 19	Over-all schematic diagram.
Fig. 12	Chassis assembly, bottom view.
Fig. 13	Socket voltage and resistance diagram.
Fig. 16	Capacitor color codes.
Fig. 17	Resistor color codes.
Fig. 18	Wiring diagram.

b. Step-By-Step Procedure.

(1) Check the trouble report to determine the probable cause of trouble. When checking the report, refer to the over-all schematic diagram (fig. 19) to localize the fault to a particular part.

(2) Inspect the equipment for damaged or broken wiring, loose screws, burned resistors, and charred wiring. If the fault cannot be located by this method, trace the circuit by making continuity measurements.

(3) When locating the fault by elimination, start at a point where the circuit is known to have continuity; proceed step by step until the fault is located.

(4) Refer to paragraphs 3 and 15 and attempt to operate the equipment; study the equipment performance checklist.

34. Equipment Required

The following equipment is needed for trouble shooting:

a. Common hand tools.

b. Vacuum-tube voltmeter, such as Electronic Multimeter TS–505/U.

c. Multimeter TS–352/U.

35. General Precautions

Whenever the CI meter is serviced, observe the following precautions very carefully; careless replacement of parts often causes new faults. Note the following:

a. Before a part is unsoldered, note the position of the leads. If the part, such as a transformer, has a number of connections, tag each of them.

b. Be careful not to damage other leads by pulling or pushing them out of the way. The oscillator circuit is very critical in regard to lead position. Leads must be replaced exactly in the same position, ±⅛ of an inch.

c. Do not allow drops of solder to fall into the equipment, since they may cause short circuits.

d. A carelessly soldered connection may create a new fault. It is very important to make well soldered joints.

e. When components in the oscillator circuits are replaced, they must be placed exactly as the original ones were placed. A part which has the same electrical value but different physical size may cause trouble in the r-f oscillator circuit. The leads must be kept the same lengths as the original wiring.

36. Trouble-Shooting Charts

a. Preliminary Procedure. When trouble occurs in the equipment, proceed as follows:

(1) Provide for favorable working conditions.

(2) Read this manual and study the schematic diagram (fig. 19).

(3) Make simple direct preliminary tests.

(*a*) Feel the tubes for filament heat.

(*b*) Check power sources and fuses.

(*c*) Check method of operation and performance.

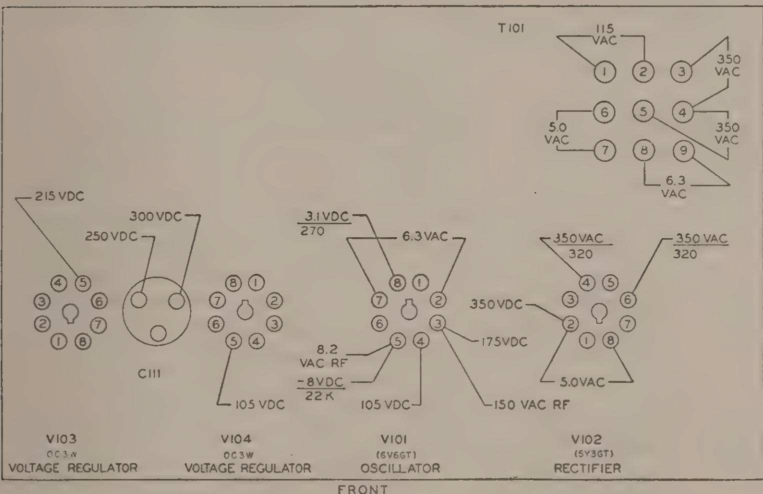
(*d*) Proceed according to *b* below.

b. TROUBLE LOCATION CHART. The following chart lists the symptoms which the repairman observes, either visually or audibly, while making a few simple tests.

Symptom	Possible trouble	Correction
1. Pilot lamp does not light.	1. Cord not plugged into source, or open.	1. Check at source and at unit (terminals No. 1 and 2 on T101).
	Fuse blown out	Check and replace.
	Transformer T101 open	Check and replace.
	Pilot lamp burned out.	Check and replace.
2. Voltage regulator tubes do not light.	2. Rectifier tube V102 is faulty.	2. Replace.
	High-voltage winding of T101 is open.	Check and replace transformer T101.
3. No apparent reading or deflection of GRID CURRENT meter.	3. Oscillator tube V101 not oscillating.	3. Check and replace tube.
	Crystal current too high.	Check operational procedure, increase GRID CURRENT control to maximum sensitivity, and decrease the CRYSTAL CURRENT control.
	Wiring shorted	Check continuity.
	Meter open	Check and replace meter.
	Transformer open	Measure a-c and d-c voltages shown in figure 13.
	R-f coil open	Measure a-c and r-f voltages shown in figure 13.
	CRYSTAL CURRENT potentiometer R142 open.	Check voltage on pin No. 4 of tube V101 as control is varied. Replace control if faulty.
	Oscillator coil open	Check all ranges on CALIBRATE position. Replace faulty coil.
4. Oscillation without crystal in socket (par. 45).	4. Wiring disturbed	4. Move wire A (fig. 12) until oscillation stops.

c. RESISTANCE CHART. The d-c resistances of T101 and V101 should correspond to those listed below. Refer to figure 13 for the socket voltages and resistances of T101, V101, V102, V103, and V104.

Transformer or tube	Terminals or pins	Resistance (ohms)
T101	1–2	11. 5.
	3–4	320.
	4–5	320.
	6–7	Less than 1.
	8–9	Less than 1.
V101	1–GR	O.
	2–GR	INF.
	3–GR	INF.
	4–GR	25,000.
	5–GR	22,000.
	7–GR	INF.
	8–GR	270.



NOTE: Place controls in positions shown below before making measurements.

CONTROL	POSITION	CONTROL	POSITION
CALIBRATE CRYSTAL .	CALIBRATE	S-A	S
X1 - X100	0	GRID CURRENT	Full counterclockwise
X10 - X1000	0	MEGACYCLES	1.00 - 1.50
CRYSTAL CURRENT ...	Full clockwise	TUNING	50

NOTES:
1. ALL VOLTAGES TO CHASSIS UNLESS OTHERWISE INDICATED.
2. RESISTANCE VALUES MEASURED WITH POWER OFF EQUIPMENT.
3. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS.

TM 5051-9

Figure 13. Sockit voltage and resistance diagram.

37. Localizing Troubles

Check the d-c and filament voltages on the socket pins of V101 (fig. 13). Correct voltages here indicate the proper operation of the power supply. Be sure to place the controls in positions given in figure 13. Measure the r-f voltages on the socket pins of V101 (fig. 13). Correct r-f voltages indicate operation of the tuned circuits and tube V101. If voltages appear correct, refer to the wiring diagram (fig. 18), and check the crystal holder network and the decade resistor assembly for wiring continuity or shorts to chassis.

38. Replacement Procedure

a. General. When failure of a component of the equipment makes replacement necessary, use the disassembly procedures given in *b* through *d* below. As the first step in any replacement procedure, remove the cover and bottom plate by removing the No. 6–32 screws on the sides and back, and in the four corners and rear edge of the bottom plate.

b. Resistors. The resistors are self-supporting and merely need to be unsoldered to be removed.

c. Fixed Capacitors. The fixed capacitors are self-supporting and merely need to be unsoldered for removal.

d. Disassembly of Meter. To disassemble or strip the equipment completely, proceed as follows:

(1) Remove all knobs and dials from the front panel (fig. 3) by loosening the set screws.

(2) Carefully remove meters M101 and M102. Be sure to remove the wire lugs from the studs before removing the three No. 6–32 screws holding each of the meters to the panel.

(3) Remove the three No. 4–40 screws through the front panel that fasten the crystal socket assembly to the front panel.

(4) Unsolder the two connecting wires (tag points) on the underside of the chassis (fig. 11).

(5) Remove the crystal socket assembly.

(6) Tag and unsolder wires from the toggle switch S108, pilot lamp E101, and potentiometers R141 and R142 (fig. 11). Remove these components from the panel.

(7) Unsolder wires and remove switch S104 (X10–X1000).

(8) Unsolder wires and remove lever switch S107 (CALIBRATE-CRYSTAL).

(9) The chassis now has been disassembled to the point that the various other switches, coils, resistors decades, etc., can be removed as desired without interference.

e. Reassembly Procedure. To reassemble the equipment, reverse the above procedures. Mount the crystal socket assembly after the oscillator coils and the tuning capacitor C101 are in place, because

this box covers the mounting screws of components on the under side of the chassis.

Section IV. FINAL TESTING AND CALIBRATION

39. Test Equipment Required for Final Testing and Calibration

The test equipment required for final testing and calibration is listed below with the respective stock numbers and technical manuals where available.

Test equipment	Stock No.	Technical manual
Q Meter TS–617A/U	3F3381	TM 11–2635
Frequency Meter Set SCR–211	2C1411	TM 11–300
Multimeter TS–352/U	3F4325–352	TM 11–5527
RF Bridge GR Type 916–A (Navy type—60094)	3F2009	TM 11–2633
Test Set I–49	3F4049	TM 11–2019
Signal Generator TS–497/URR	3F4325–497	TM 11–5030
Precision capacitor type 722–D, General Radio Co., or equal.		

40. Readjustment of Capacitor C103

Make this adjustment only if the resistance decades or the crystal socket assembly has been replaced. The capacity from point P (fig. 3) to ground (with the CALIBRATE-CRYSTAL switch S107 in the CALIBRATE position) must equal that of point Q (figs. 12 and 19) to ground (with switch S107 in the CRYSTAL position). Capacitor C103 (fig. 12) is varied until these two capacities are equal. These capacities are measured by use of Q Meter TS–617A/U, and precision capacitor type 722–D, General Radio Co., or equal (fig. 14). A crystal-controlled, 400-kc oscillator (frequency generator) is used to stabilize the frequency of the Q meter; a standard inductance coil is used to tune the Q meter to resonance. Connect these units together as shown in figure 14, using No. 12 AWG solid copper wire supported on 2-inch centers.

a. Measurement of Capacity From Point P to Ground. Place the CALIBRATE-CRYSTAL switch S107 in the CALIBRATE position and proceed as follows:

(1) Connect a wire from one of the rivets holding the polystyrene crystal socket to the HIGH terminal of the precision capacitor (fig. 14). This wire should be stiff, bare, located as far as possible from anything grounded, and not larger than No. 16 AWG bare copper tinned wire. The same physical relationship should exist for every measurement with the wire connection as short as possible and kept away

from ground. Arch the wire about 3 inches away from ground as soon as possible after it leaves the terminal.

(2) Connect a stiff No. 16 AWG wire from the most convenient point of the panel or chassis of the equipment being measured to the ground terminal of the precision capacitor. It is more important to keep the wires in the same physical relationship with each other and to ground, when the measurement of capacity is made, than to shorten the wires.

(3) Connect the ground terminal on the precision capacitor to a good *ground*, such as a water pipe, a steam pipe, or a BX electric cable if it is well grounded; errors due to capacity between the equipment being tested and your own body thus will be eliminated.

(4) Disconnect the wire to the HIGH terminal but allow the wire to remain near the terminal, set the precision capacitor to 200 $\mu\mu$f, and tune the Q meter to resonance by using a standard inductance coil (fig. 14). Reconnect the wire to

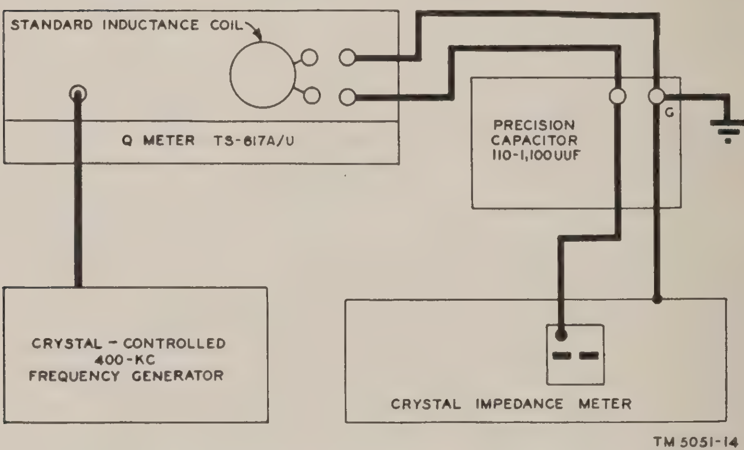


Figure 14. Test circuit for measurement of points P and Q to ground.

the HIGH terminal, and rotate the precision capacitor dial until resonance is reached again. The capacitance value of P to ground is the difference in reading between 200 $\mu\mu$f and the new setting of the precision capacitor dial.

b. Measurement of Capacity From Point Q to Ground.

(1) Place the CALIBRATE—CRYSTAL switch S107 in the CRYSTAL position and proceed as described in *a* above, except that the wire connected to the HIGH terminal of the precision capacitor must be moved from point P to point Q (figs. 12 and 19). To make this connection, solder

a short length of wire to point Q, remove the button in the bottom plate of the CI meter, and bringing the wire through the hole.

(2) Adjust variable capacitor C103 with a nonmetallic screw driver, or other means, through a ¼-inch diameter hole in the bottom plate until the measured capacity is equal to the capacity measured from P to ground (*a* (4) above).

41. Measurement and Adjustment of Frequency

Note. These adjustments have been made during manufacture. Do not repeat these adjustments unless an oscillator coil has been replaced.

The overlap of the frequency ranges should be approximately as tabulated below. Measure the frequency of oscillation with Frequency Meter Set SCR–211 connected to r-f cable assembly W101 (fig. 11). The frequency overlap can be adjusted only by adding or removing turns from the tuned plate or grid inductance.

a. Connect the CI meter to the frequency meter with cable assembly W101.

b. Place a composition resistor, with value listed in the second column of the table below, into the crystal holder.

c. Place S106 in S position, S107 in CRYSTAL position; place S108 to ON position; set GRID CURRENT control R141 to maximum; increase CRYSTAL CURRENT control until a convenient reading of GRID CURRENT is obtained. Read the frequency meter.

MEGACYCLES switch (S105) position (mc)	Crystal socket resistance (ohms)	TUNING dial (I–103) position	
		0-mc position	100-mc position
1.00–1.50	1, 000	0. 78	1. 54
1.50–2.25	500	1. 16	2. 34
2.25–3.40	220	1. 70	3. 47
3.40–5.10	120	2. 59	5. 28
5.10–7.50	55	3. 80	7. 83
7.50–10.00	25	4. 88	10. 60
10.00–15.00	15	7. 28	15. 80

42. Frequency Correlation between CRYSTAL and CALIBRATE Positions

Check the frequency correlation between CRYSTAL and CALIBRATE positions (fig. 3) as follows:

a. Under operating conditions, move switch S105 to range 10.0 to 15.0 MEGACYCLES.

b. Set the decade resistors to 10 ohms.

c. Switch to CALIBRATE position.

d. Set R141 (GRID CURRENT meter sensitivity) control to maximum. Increase the CRYSTAL CURRENT control R142 until a meter reading of 150 ua (microampere) is obtained.

e. Adjust the TUNING capacitor dial to obtain 12.5 mc. Measure this frequency with Radio Receiver BC–348–M; Radio Receiver BC–342 may be used if the latter is not available. Zero-beat the signal with the bfo of the receiver (fig. 6).

f. Switch to CRYSTAL position.

g. Place the shorting switch S106 in the S position.

h. Insert a 10-ohm, ½-watt composition resistor into the crystal socket.

i. Note the audio output frequency of the receiver (ch. 4). The difference in frequency caused by moving S107 from CRYSTAL to CALIBRATE should be less than 1,000 cps. If this difference frequency is greater than 1,000 cps, compress or extend the length of coil L105 (fig. 19) until the frequencies at CRYSTAL and CALIBRATE positions are approximately equal. Coil L105 is ½-inch in diameter and consists of 1 to 4 turns of No. 16 AWG gage tinned copper wire in series between one crystal unit socket terminal and the lead entering the shield assembly on the grid side; *L105 is present only in those CI meters which require it.* Adjust L105 only after adjusting C113 (par. 43*k*).

43. Performance Test

Note. These adjustments have been made during manufacture. Do not repeat these adjustments unless an oscillator coil has been replaced.

Test the performance of the CI meter for each position of band switch S105 (MEGACYCLES) as follows:

a. With the CALIBRATE-CRYSTAL switch S107 in the CALIBRATE position, measure the capacity from point P to ground with Q Meter TS–617A/U in conjunction with precision capacitor, type 722–D, General Radio Co., or equal, as described in paragraph 40.

b. Place the CALIBRATE-CRYSTAL switch S107 in the CRYSTAL position and vary C103 until the measured capacity from point Q to ground is equal to that obtained when measuring from point P to ground. (It is not necessary to repeat the procedure of *a* and *b* above for successive band switch positions.)

c. Place the CALIBRATE-CRYSTAL lever switch S107 in the CALIBRATE position.

d. Set the decade resistors successively to the values listed in the table below for the band being tested.

e. Adjust the TUNING dial to obtain the corresponding frequency listed.

f. Rotate the GRID CURRENT control in a clockwise direction until all the resistance is in the meter shunt circuit.

g. Adjust the CRYSTAL CURRENT control R142 until 150 ua or approximate convenient value of rectified GRID CURRENT indication is obtained.

h. Place the CALIBRATE-CRYSTAL lever switch in the CRYSTAL position.

i. Place the load capacity shorting switch S106 in the S position (fig. 3).

j. Insert the same value of resistance as set in *d* above into the crystal socket. This resistance must be of the composition type with leads as short as possible. The r-f resistance of the resistor should be within ±1 percent of desired value as measured on RF Bridge GR Type 916–A (Navy type—60094).

k. The GRID CURRENT meter indication must not vary more than ±3 percent or 4.5 ua from the 150 ua point. On capacitor C113, there are two solder dots, one on the stationary and one on the movable disk. When the disk is turned so that these dots are on opposite sides, capacitor C113 is at its minimum value. Place capacitor C113 at minimum value and slowly increase capacitance until the change of GRID CURRENT meter reading between CALIBRATE and CRYSTAL positions of S107 is a minimum. Adjust C113 prior to adjusting L105 (see note at beginning of paragraph).

l. Usually, setting capacitor C113 at ⅓ of maximum value is satisfactory for all units. This setting is made before performance tests are started.

Table of decade resistor values

Range (mc)	Resistance value (ohms)	Frequency (mc)
1.00–1.50	1, 000	1. 30
1.50–2.25	500	2. 00
2.25–3.40	220	3. 00
3.40–5.10	120	4. 00
5.10–7.50	55	6. 00
7.50–10.00	25	8. 50
10.00–15.00	15	12. 00

44. Checking Load Capacitance Chart

The load capacitance chart is prepared from data obtained by measuring the actual capacitance value (within ±.1 $\mu\mu$f) of capacitor C102 (LOAD CAPACITY, figs. 3 and 11) in the circuit with shorting switch C106 in the A position. Plotting points are taken at every dial division from 0 to 12 on the dial, every 2 divisions from 12 to 30, and every 5 divisions from 30 to 100. Connections are made as shown in figure 15. The frequency stability of Q Meter TS–617A/U must be very good. Accomplish this by controlling the Q meter

with a crystal-controlled, 400-kc oscillator. The wiring used between units must be No. 12 AWG solid copper wire supported on 2-inch centers. The Q meter is tuned to resonance by using a standard inductance coil with the precision capacitor set at 200 $\mu\mu f$ and the LOAD CAPACITY dial set at zero. The LOAD CAPACITY dial is then moved 1 division up from 0 to 12 on the dial, 2 divisions from 12 to 30, and 5 divisions from 30 to 100; the Q meter is returned to resonance with the precision capaicitor. The difference in reading of the precision capactor is the value of capacitance added by moving C102. Record this value and proceed with the reading of the next point. The data are plotted as shown in figure 4.

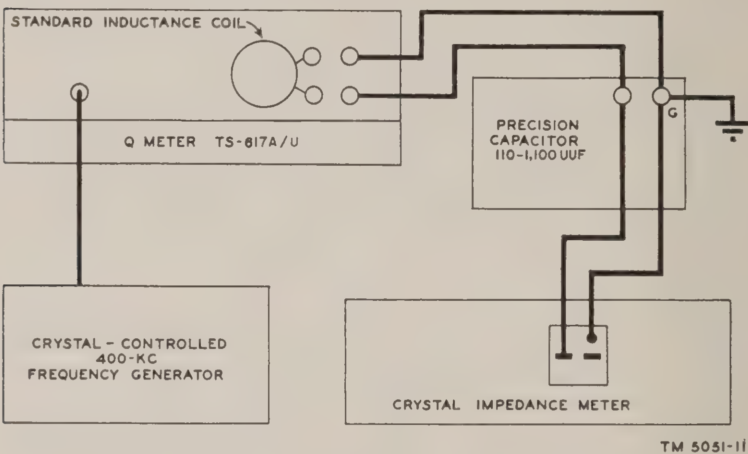


Figure 15. Test circuit for calibration of LOAD CAPACITY dial.

45. Oscillation Test

With CALIBRATE-CRYSTAL switch S107 in the CRYSTAL position (no crystal in socket), rotate TUNING knob controlling capacitor C101 through 180° for each band switch position with R141 and R142 advanced in their extreme clockwise direction. No self-controlled oscillation should be observed either by and indication of grid current other than residual grid current, or by the presence of a signal on a communication receiver. The condition of oscillation can be eliminated by proper placement of grid and plate circuit wiring. During the replacement of parts and repairs, these wires may have been disarranged. Position of wire A (fig. 12) is very critical and *must be replaced within 1/16 of an inch;* a small movement of this wire will put the equipment into a condition of oscillation.

CHAPTER 6
SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

46. Packaging Crystal Impedance Meter TS–330/TSM

a. Cushion the set on all surfaces with cells or pads fabricated of corrugated fiberboard.

b. Obtain the proper amount of desiccant, as prescribed in table II, section E of Joint Army-Navy Specification JAN–P–116, and place the cushioned set, together with technical manuals and desiccant, within a close-fitting regular slotted style corrugated fiberboard box.

c. Seal the entire closure with gummed Kraft tape and blunt all corners of the box.

d. Place the boxed set within a moisture-vaporproofed barrier, type 1, and heat-seal the closure.

e. Place the moisture-vaporproofed set within a second close-fitting regular slotted style corrugated fiberboard box, and seal the entire closure with water-resistant tape or adhesive.

f. Overwrap the boxed set in waterproof barrier material, type L–2 or M.

g. Completely seal all joints, seams, and closures with adhesive or other suitable seal equal in moisture resistance to that of the body material in accordance with approved specifications.

47. Packing and Marking

Materials used in packing, as described in the following paragraphs, should comply with the requirements as referenced in Joint Army-Navy Specification JAN–P–100.

a. Place the equipment, packaged as described in paragraph 46, within a nailed wooden box lined inside with a 2-inch thickness of excelsior compacted to 3 pounds per cubic foot. The shipping container should *not* be lined with a waterproof bag.

b. For oversea shipment only, the shipping container should be strapped in accordance with approved techniques.

48. Methods of Demolition

a. Smash. Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.

b. Cut. Use axes, handaxes, machetes.

c. Burn. Use gasoline, kerosene, oil, flame throwers, incendiary grenades.

d. Explode. Use firearms, grenades, TNT.

e. Dispose. Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

f. Other. Use anything immediately available for destruction of this equipment.

49. Destruction of Components

When ordered by your commander, destroy all equipment to prevent its being used or salvaged by the enemy.

a. Smash the crystal, controls, tubes, coils, switches, capacitors, and transformers.

b. Cut cords and wiring.

c. Burn cords, resistors, capacitors, coils, wiring, and technical manuals.

d. Bend the panel, case, and chassis.

e. Bury or scatter all remaining parts of the equipment.

f. DESTROY EVERYTHING.

APPENDIX I
REFERENCES

Note. For availability of items listed, check SR 310–20–3 and SR 310–20–4.

1. Army Regulations

AR 380–5	Safeguarding Military Information.

2. Supply Publications

SB 11–76	Signal Corps Kit and Materials for Moisture- and Fungi-Resistant Treatment.

3. Technical Literature on Auxiliary Equipment and Test Equipment

TM 11–5527	Multimeter TS–352/U.
TO 16–40BC224–3	(Air Force) Radio Receiver BC–348–M.
TM 11–300	Frequency Meter Sets SCR–211–( ).
TM 11–472	Repair and Calibration of Electrical Measuring Instruments.
TM 11–850	Radio Receivers BC–312–(*), BC–342–(*), BC–314–(*), and BC–344–(*).
TM 11–2019	Test Set I–49.
TM 11–2530	Frequency Standard TS–308/U.
TM 11–2540	Quartz Crystals—Theory, Fabrication, and Performance Measurements.
TM 11–2606	Test Set AN/FSM–3, Tool Equipment TK–40/FSM–3, and Maintenance Kit MK–40/FSM–3 (Formerly Depot Crystal Equipment AN/FSM–1).
TM 11–2627	Tube Testers I–177 and I–177–A.
TM 11–2633	RF Bridge Type 916–A.
TM 11–2635	Q Meter TS–617A/U.
TM 11–4001	Repair Instructions for Radio Receivers BC–312, –A, –C, –D, –E, –F, –G, –J, –L, –M, –N, –HX, and –NX, and BC–342, –A, –C, –D, –F, –J, –L, –M, and –N.
TM 11–5030	Signal Generator TS–497/URR.

4. Painting, Preserving, and Lubrication

TB SIG 13	Moistureproofing and Fungiproofing Signal Corps Equipment.
TB SIG 66	Winter Maintenance of Signal Equipment.
TB SIG 69	Lubrication of Ground Signal Equipment.
TB SIG 72	Tropical Maintenance of Ground Signal Equipment.
TB SIG 75	Desert Maintenance of Ground Signal Equipment.
TB SIG 123	Preventive Maintenance Practices for Ground Signal Equipment.
TB SIG 219	Operation of Signal Equipment at Low Temperatures.

5. Decontamination

TM 3–220	Decontamination.

6. Demolition

FM 5–25	Explosives and Demolitions.

7. Military (JAN) Specifications

a. Joint Army-Navy Packaging Specifications.

JAN–D–169	Desiccants (activated).

b. Packaging and Packing for Overseas Shipment.

JAN–P–100	General specification.
JAN–P–106A	Boxes, wood, nailed.
JAN–P–116	Preservation, methods of.
JAN–P–125	Barrier Materials, Waterproof, Flexible.
JAN–P–131	Barrier Material; Moisture-Vaporproof, Flexible.

c. U. S. Army Specifications.

100–2E	Marking shipments by contractors, standard specification for (and Signal Corps supplement thereto).

d. Signal Corps Instructions.

720–7	Standard Pack.
726–15	Marking of Interior Containers (for Signal Corps Equipment).

8. Other Publications

MIL–C–3098	Crystal Units, Quartz.
MIL–C–10405 (Sig C).	Crystal Units, Quartz, Pressure and Spacer Mounted.
SR 310–20–3	Index of Training Publications (Field Manuals, Training Circulars, Firing Tables and Charts, Army Training Programs, Mobilization Training Programs, Graphic Training Aids, Joint Army-Navy-Air Force Publications, and Combined Communications Board Publications).
SR 310–20–4	Index of Technical Manuals, Technical Regulations, Technical Bulletins, Supply Bulletins, Lubrication Orders, Modification Work Orders, Tables of Organization and Equipment, Reduction Tables, Tables of Allowances, Tables of Organization, and Tables of Equipment.
SR 700–45–5	General-Unsatisfactory Equipment Report (Reports Control Symbol (CSGLD–247)).
SR 745–45–5	Report of Damaged or Improper Shipment (Reports Control Symbols CSGLD–66 (Army)).
TB SIG 123	Preventive Maintenance Practices for Ground Signal Equipment.
TB SIG 178	Preventive Maintenance Guide for Radio Communication Equipment.
TM 11–453	Shop Work.
TM 11–455	Radio Fundamentals.
TM 11–660	Introduction to Electronics.
TM 11–4000	Trouble Shooting and Repair of Radio Equipment.
TM 38–650	Basic Maintenance Manual.

APPENDIX II

IDENTIFICATION TABLE OF PARTS

Note. The fact that a part is listed in this table is not sufficient basis for requisitioning the item. Requisitions must cite an authorized basis, such as T/O & E, T/E, T/A, SIG 6, SIG 7 & 8, SIG 7–8–10, list of allowances of expendable material, or another authorized supply basis. The Department of the Army Supply Catalog applicable to the equipment covered in this manual is SIG 7 & 8–TS–330/TSM. For an index of available supply catalogs in the signal portion of the Department of the Army Supply Catalog, see the latest issue of SIG 1, Introduction and Index.

Ref symbol	Name of part and description	Function of part	Signal Corps stock No.
	CRYSTAL IMPEDANCE METER TS–330/TSM: 19″ lg x 10½″ wd x 7″ h o/a; frequency continuously varies from 1 mc to 15 mc in 7 ranges, decade resistors from 0–99 ohms in 1-ohm steps, 0–990 ohms in 10-ohm steps, and 0–9900 ohms in 100-ohm steps, decade resistor range selection by means of toggle sw; operates from 115 v ac, 50-1,720 cyc line; metal case, black wrinkle finish; incl r-f pick-up cables assem, calibration chart, and two instruction books; designed for rack mtg; p/o Army-Navy Crystal Test Set AN/TSM–3.	R-f crystal impedance meter; measures series-resonant and antiresonant resistances of piezoelectric crystals.	3F4325–330
W102	CABLE ASSEMBLY, power: Sig C Cord CX–112/U; type S, 2 cont, No. 16 AWG; 6 ft excluding terminations; male plug P101 assembled on one end.	Connects CI meter to 115-volt a-c, 1,750-cycle source.	3E6000–112
W101	CABLE ASSEMBLY, radio-frequency pick-up; Army-Navy type RG–8/U, JAN C–17 cable; 4 ft excluding terminations; PL–259 assembled on one end.	Provides connection to external frequency meter.	3E7350-2.58.2

C104	CAPACITOR, fixed: silver mica dielectric; JAN type CM20C300J; 30 $\mu\mu f$ $\pm 5\%$; 500 vdcw.	Compensating capacitor; used to equalize the capacity between the decade resistors to ground and the crystal socket assembly to ground.	3K2030032
C105	CAPACITOR, fixed: mica dielectric; JAN type CM20C510J; 51 $\mu\mu f$ $\pm 5\%$; 500 vdcw.	Blocks rectified grid current	3K2051032
C106, C107, C108	CAPACITOR, fixed: paper dielectric; JAN type CP53B1EF254K; single sect; .25 μf $\pm 10\%$; 600 vdcw; HS metal case.	C106—Bypasses rf from cathode of V101 to ground. C107—Bypasses rf from screen of V101 to ground. C108—Bypasses r-f currents to ground, isolates r-f current from power supply.	3DA250–362
C109	CAPACITOR, fixed: silver mica dielectric; JAN type CM35C103K; .01 μf $\pm 10\%$; 300 vdcw.	Prevents d-c current from flowing in feedback circuit.	3K3510331
C111	CAPACITOR, fixed: dry electrolytic; JAN type CE42E100R; 2 sect; 10–10 uf, 450 vdcw; working temp range $-40°$ C to $+65°$ C; HS metal can.	Filters rectified output of power supply.	3DB10–168
C112	CAPACITOR, fixed: paper dielectric; JAN type CP28-A1EF302M; single sect; .003 μf $\pm 20\%$ 600 vdcw; HS metal can.	Line filter; bypasses rf from the input power line to ground.	3DA3–133
C101	CAPACITOR. variable: air dielectric; 2 sect; 7.8 to 140 $\mu\mu f$; 19 plates per sect; 180° rotation.	Tunes the grid and plate coils of V101	3D9140V–31
C102	CAPACITOR, variable: air dielectric; single sect; 4.5 to 102 $\mu\mu f$; 19 plates; 360° rotation	Adds series capacitance to crystal circuit for antiresonance tests.	3DK9100V–31
C103	CAPACITOR, variable: air dielectric; single sect; JAN type CT1C040; 5 to 42 $\mu\mu$; SLC; 13 plates; 360° rotation.	Compensating capacitor used to equalize the capacity between the decade resistors to ground and the crystal socket assembly to ground.	3D9042V–7
C113	CAPACITOR, variable: ceramic; compression type, single sect; 1.5 to 7.0 $\mu\mu f$; 500 vdcw.	Compensates for effects of interelectrode and stray capacity.	3D9007V–17

Ref symbol	Name of part and description	Function of part	Signal Corps stock No.
N104	CHART: calibration; Crystal Impedance Meter TS–330/TSM serial No. blank, load capacity dial; black lines and printing, green chart lines.	Translates the dial markings of the LOAD CAPACITY dial into $\mu\mu$f.	
L101, L102	COIL ASSEMBLY, RF: grid + plate oscillator coil; four coils, 335 uh, 126 uh, 61 uh, 23.5 uh on one form for ranges of 1.0 to 1.5 mc, 1.5 to 2.25 mc, 2.25 to 3.4 mc, and 3.4 to 5.1 mc, respectively.	L101—Grid oscillator coils for ranges between 1.0 and 5.1 mc. L102—Plate oscillator coils for ranges between 1.0 and 5.1 mc.	3C4052A
L103, L104	COIL ASSEMBLY, RF: plate + grid oscillator coil; three coils, 10.5 uh, 6.5 uh, and 2.6 uh on one form for ranges of 5.1 to 7.5 mc, 7.5 to 10.0 mc, and 10.0 to 15.0 mc, respectively.	L103—Grid oscillator coils for ranges between 5.1 and 15.0 mc. L104—Plate oscillator coils for ranges between 5.1 and 15.0 mc.	3C4052A–1
P101	CONNECTOR, plug: 2 flat parallel blades; 10 amp, 250 v.	Line plug for standard 115-volt receptacle.	6Z7565.3
P102	CONNECTOR, plug: Plug PL-259; single round male cont; JAN type PL–259; for 50–ohm r-f cable.	Connects W101 to J105	2Z7226–259
J101, J102, J103, J104	CONNECTOR, receptacle: single female cont; banana type connector.	J101—Provides for connection of test lead to chassis. J102—Provides for measurement of voltage across the crystal under test. J103—Same as J102 J104—Same as J101	2Z5594.5
J105	CONNECTOR, receptacle: Army-Navy and JAN type SO–239; single round female cont; straight type; for 50-ohm r-f cable.	Connects r-f cable assembly W101 to CI meter.	2Z8799–239
L102	DIAL: for capacitor, incl friction drive and vernier; brass dial with bakelite knob; marked 0 to 100 over 180° arc.	LOAD CAPACITY dial; varies C102	2Z3723–167
I103	DIAL: for capacitor, incl friction drive; brass dial with bakelite knob; marked 0 to 100 over 180° arc.	TUNING capacitor dial; varies C101	2Z3723–168

H101	FITTING: conduit; straight compression type for connecting cable to box, threaded connection to box, compression connection to cable.	Clamps power cable assembly W102 to chassis.	6Z4847–3
F101	FUSE, cartridge: 1 amp; 250 v; glass body; ferrule term; Littelfuse 3AG #312001.	Line fuse; protects the CI meter from current overload.	3Z1926
E103	FUSEHOLDER: extractor post type; for single 3AG cartridge fuse; bakelite; 250 v, 15 amp max; Littelfuse part #341001.	Holds a-c line fuse F101	3Z3275
E106	INSULATOR, stand-off: round post shape; JAN type NP2W0106; white porcelain; ¾″ lg; ⅜″ OD with two #6–32 tapped holes in each end.	Stand-off insulator in crystal socket assembly.	6G3601–06
E104, E105	KNOB: round; black bakelite; ¼″ flatted shaft; push-on type; engraved arrow; ⅞″ dia x ½″ h; ICA #1147.	E104—Knob for GRID CURRENT control; varies R141. E105—Knob for CRYSTAL CURRENT control; varies R142.	2Z5822–385
E107 E110	KNOB: bar; black bakelite for ¼″ dial shaft engraved through index line, white filled.	Knobs for LOAD CAPACITY, tuning, verniers.	2Z5838
R101	LAMP, incandescent: 6 to 8 v, .25 amp; bulb clear, T–3¼ miniature bayonet base; Navy type TB–11; GE Mazda #44.	Pilot lamp; indicates the presence of line voltage.	2Z25927
I101	LIGHT, indicator: with lens; ½″ dia red lens; miniature bayonet base, bulb T–3–¼; 6 v, 1½ w; Drake Mfg #50.	Lamp assembly for lamp E101	2Z5991
M101	METER, ammeter: dc; JAN type MR26W200DCUA; 0 to 200 ua; round HS metal case; ±2% accuracy for full scale reading; 40 division GRID CURRENT meter; scale; Weston model 1021, 200 ua.	Indicates the magnitude of oscillation of V101 by measuring its grid current.	3F87231
M102	METER, ammeter: thermo rf, for use with ext thermocouple H102; scale marked 0 to 100 ma; round HS metal case; ±2% accuracy for full scale reading; calibrated with thermocouple E102; 16 scale divisions; Weston Model 1023 for use with 0–100 RFMA thermocouple.	CRYSTAL CURRENT meter; measures the magnitude of r-f current through the crystal under test.	3F910–58

Ref symbol	Name of part and description	Function of part	Signal Corps stock No.
H103	NUT, lock: speed nut type; $\frac{3}{32}''$ thk; 1'' OD; Graybar #140.	Locknut for clamp H101	6L3680-8.3
R101	RESISTOR, fixed: comp; 1 ohm ±1%; ½ w; neg temp coef; Concarbon type X ½.	Calibration resistor; part of decade resistor.	3Z5911-111
R102	RESISTOR, fixed: comp; 2 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z5992-77
R103	RESISTOR, fixed: comp; 3 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z5993-70
R104	RESISTOR, fixed: comp; 4 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z5994-43
R105	RESISTOR, fixed: comp; 5 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z5995-76
R106	RESISTOR, fixed: comp; 6 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z5996-42
R107	RESISTOR, fixed: comp; 7 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z5997-29
R108	RESISTOR, fixed: comp; 8 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z5998-25
R109	RESISTOR, fixed: comp; 9 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z5999-14
R110	RESISTOR, fixed: comp; 10 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6001-143
R111	RESISTOR, fixed: comp; 20 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6002-80
R112	RESISTOR, fixed: comp; 30 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6003-75
R113	RESISTOR, fixed: comp; 40 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6004-56

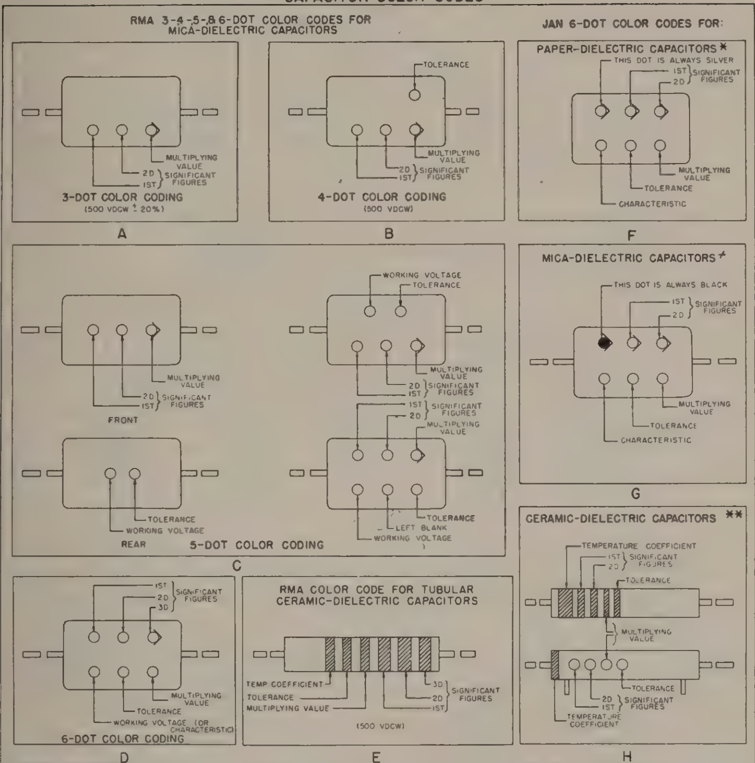
R114	RESISTOR, fixed: comp; 50 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6005–193
R115	RESISTOR, fixed: comp; 60 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6006–47
R116	RESISTOR, fixed: comp; 70 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6007–21
R117	RESISTOR, fixed: comp; 80 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6008–25
R118	RESISTOR, fixed: comp; 90 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6009–11
R119	RESISTOR, fixed: comp; 100 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6010–238
R120	RESISTOR, fixed: comp; 200 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6020–267
R121	RESISTOR, fixed: comp; 300 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6030–135
R122	RESISTOR, fixed: comp; 400 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6040–99
R123	RESISTOR, fixed: comp; 500 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6050–244
R124	RESISTOR, fixed: comp; 600 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6060–101
R125	RESISTOR, fixed: comp; 700 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6070–33
R126	RESISTOR, fixed: comp; 800 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6080–69
R127	RESISTOR, fixed: comp; 900 ohms ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6090–37
R128	RESISTOR, fixed: comp; 1 K ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6100–288
R129	RESISTOR, fixed: comp; 2 K ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6200–206

Ref symbol	Name of part and description	Function of part	Signal Corps stock No.
R130	RESISTOR, fixed: comp; 3 K ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6300–217
R131	RESISTOR, fixed: comp; 4 K ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6400-125
R132	RESISTOR, fixed: comp; 5 K ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6500–272
R133	RESISTOR, fixed: comp; 6 K ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6560–82
R134	RESISTOR, fixed: comp; 7 K ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6570–52
R135	RESISTOR, fixed: comp; 8 K ±1%; ½ w; neg temp coef; Concarbon type X ½.	Same as R101	3Z6580–43
R136	RESISTOR, fixed: comp; 9 K±1%; ½ w; neg temp coef; Concarbon type X ½	Same as R101	3Z6590–26
R137, R138	RESISTOR, fixed: comp; JAN type RC30BF222J; 2200 ohms ±5%; 1 w; F characteristic	R137—Feedback resistor. Drops rf in tuned grid circuit of V101 R138—Feedback resistor. Drops rf in tuned plate circuit of V101	3RC30BF222J
R139	RESISTOR, fixed: comp; JAN type RC30BF223J; 22 K±5%; 1 w; F characteristic	Grid leak resistor for V101	3RC30BF223J
R140	RESISTOR, fixed: comp; JAN type RC30BF271K; 270 ohms±10%; 1 w; F characteristic	Cathode bias resistor for V101	3RC30BF271K
R143, R144, R145	RESISTOR, fixed: WW; JAN type RW32F162; 1600 ohms±5%; 12 w	R143—Filters output of V102 R144—Same as R143 R145—Filters output of V102 and regulates d-c voltage to plate of V101	3RW25521

R141	RESISTOR, variable: comp; JAN type RV4ANFK102A; 1 K±10%; 2 w	GRID CURRENT control resistor which adjusts the sensitivity of meter M101	3RV31018
R142	RESISTOR, variable: comp; JAN type RV4ANFK253A; 25 K±10%; 2 w	CRYSTAL CURRENT control resistor; controls magnitude of oscillation by varying the voltage on the screen grid of V101	3RV42524
X101, X102, X103, X104	SOCKET, tube: JAN type TSB8T102	Sockets for V101, V102, V103, V104	2Z8678.327
S107	SWITCH, lever: two position, nonlocking; DPDT; Centralab #CRL–9167	CALIBRATE—CRYSTAL control; switches either the test crystal or substitution decade resistors into oscillator circuit	3Z9580-2.5
S101	SWITCH, rotary: 4 pole, 10 position; 4 sect; Centralab #CRL–11833	Selects a substitution resistor	3Z9825–58.183
S102	SWITCH, rotary: 4 pole, 10 position; 4 sect; Centralab #CRL–11834	Same as S101	3Z9825–58.184
S105	SWITCH, rotary: 2 pole, 7 position; 2 sect; Centralab #CRL–11832	MEGACYCLES switch; changes frequency range by selecting various inductances.	3Z9825–39.2
S106	SWITCH, rotary: 1 pole, 2 position; Centralab #CRL–11831.	S—A control; shorts out C102 (S position) for series-resonant test of crystal.	3Z9825–39.1
S103, S104	SWITCH, toggle: DPDT; JAN type ST52N; 30 amp, 30 v dc; locking action, position 1—normally closed, position 2—normally open.	S103—X1—X100 switch; changes resistance decades on switch S102. S104—X10–X1000 switch; changes resistance decades on switch S102.	
S108	SWITCH, toggle: SPST; JAN type ST42A; 20 amp, 30 v dc.	Power switch; controls ac into the CI meter.	3Z9863-42A
E102	THERMOCOUPLE: 100 ma; heater type vacuum element; calibrated for use w/Weston model #1023 instrument; Weston type B.	Thermocouple for M102 (CRYSTAL CURRENT meter).	3F34540–100.1

Ref symbol	Name of part and description	Function of part	Signal Corps stock No.
T101	TRANSFORMER, power: filament and plate type; input 115 v, 50–1, 720 cyc, single phase; 3 output windings; secd #1—700 v CT at 35 ma, secd #2—5 v 3 amp, secd #3—6.3 v at 2.5 amp; Electransf 2280–1.	Power supply transformer	2Z9613.645
V101	TUBE, electron: JAN 6V6GT; beam power amplifier	Oscillator tube	2J6V6GTY
V102	TUBE, electron: JAN 5Y3GT; full wave rectifier	Rectifier tube	2J5Y3GT
V103, V104	TUBE, electron: JAN OC3/VR105 (to be replaced by JAN OC3W); voltage regulator.	Regulate d-c voltage to plate and screen of V101.	2J0C3W

CAPACITOR COLOR CODES



COLOR	SIGNIFICANT FIGURE	MULTIPLYING VALUE			RMA VOLTAGE RATING
		RMA MICA-AND CERAMIC-DIELECTRIC	JAN MICA-AND PAPER-DIELECTRIC	JAN CERAMIC-DIELECTRIC	
BLACK	0	1	1	1	-
BROWN	1	10	10	10	100
RED	2	100	100	100	200
ORANGE	3	1,000	1,000	1,000	300
YELLOW	4	10,000	10,000		400
GREEN	5	100,000			500
BLUE	6	1,000,000			600
VIOLET	7	10,000,000			700
GRAY	8	100,000,000		0.01	800
WHITE	9	1,000,000,000		0.1	900
GOLD	-	0.1	0.1		1,000
SILVER	-	0.01	0.01		2,000
NO COLOR	-				500

NOTES

* THE SILVER DOT IDENTIFIES THIS MARKING FOR WORKING VOLTAGES SEE JAN TYPE DESIGNATION CODE

✝ THE BLACK DOT IDENTIFIES THIS MARKING FOR WORKING VOLTAGES SEE JAN TYPE DESIGNATION CODE

** CAPACITORS MARKED WITH THIS CODE HAVE A VOLTAGE RATING OF 500 VDCW EITHER THE BAND OR DOT CODE MAY BE USED FOR BOTH INSULATED (AXIAL-LEAD) OR UNINSULATED (RADIAL-LEAD) CAPACITORS

RMA RADIO MANUFACTURERS ASSOCIATION

JAN JOINT ARMY-NAVY

THESE COLOR CODES GIVE CAPACITANCES IN MICROMICROFARADS

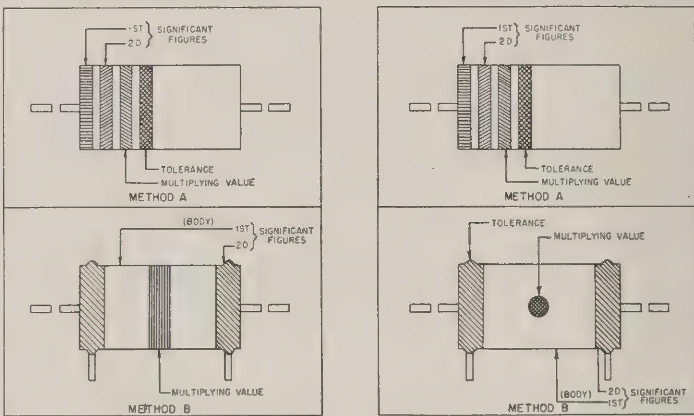
TL 32453S

Figure 16. Capacitor color codes.

RESISTOR COLOR CODES

RMA COLOR CODE FOR FIXED COMPOSITION RESISTORS*

JAN COLOR CODE FOR FIXED COMPOSITION RESISTORS†



COLOR	SIGNIFICANT FIGURE	MULTIPLYING VALUE	TOLERANCE (%)
BLACK	0	1	± -
BROWN	1	10	± 1
RED	2	100	± 2
ORANGE	3	1,000	± 3
YELLOW	4	10,000	± 4
GREEN	5	100,000	± 5
BLUE	6	1,000,000	± 6
VIOLET	7	10,000,000	± 7
GRAY	8	100,000,000	± 8
WHITE	9	1,000,000,000	± 9
GOLD	—	0.1	± 5
SILVER	—	0.01	± 10
NO COLOR	—	—	± 20

NOTES

* INSULATED FIXED COMPOSITION RESISTORS WITH AXIAL LEADS ARE DESIGNATED BY A NATURAL TAN BACKGROUND COLOR NON-INSULATED FIXED COMPOSITION RESISTORS WITH AXIAL LEADS ARE DESIGNATED BY A BLACK BACKGROUND

† RESISTORS WITH AXIAL LEADS ARE INSULATED. RESISTORS WITH RADIAL LEADS ARE NON-INSULATED

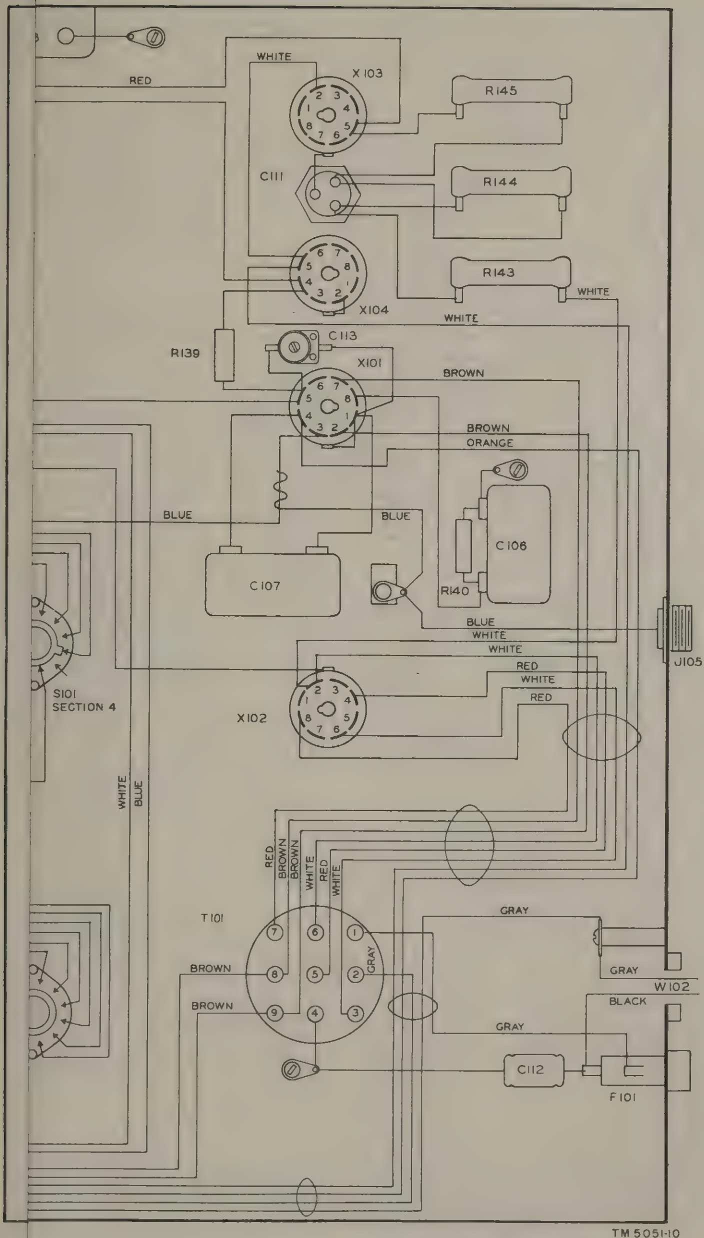
RMA RADIO MANUFACTURERS ASSOCIATION

JAN JOINT ARMY-NAVY

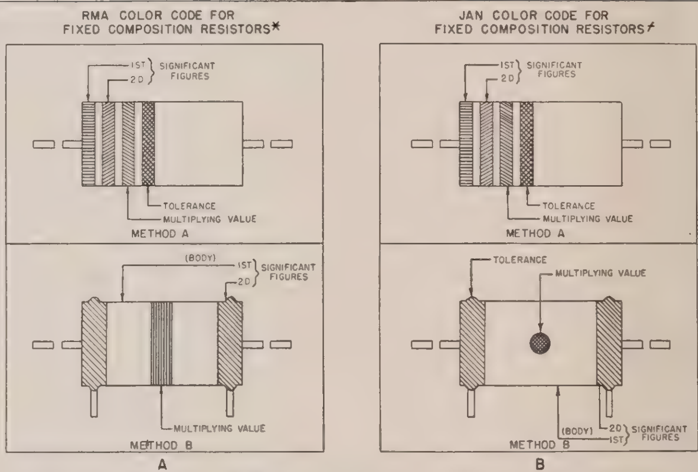
THESE COLOR CODES GIVE ALL RESISTANCE VALUES IN OHMS

TL32454S

Figure 17. Resistor color codes.


X103
WHITE
RED
R145
C111
R144
R143
WHITE
X104
WHITE
C113
R139
X101
BROWN
BROWN
ORANGE
BLUE
BLUE
C106
C107
R140
BLUE
WHITE
WHITE
J105
RED
WHITE
RED
S101
SECTION 4
X102
WHITE
BLUE
RED
BROWN
BROWN
WHITE
RED
WHITE
T101
GRAY
GRAY
BROWN
BROWN
GRAY
W102
BLACK
GRAY
C112
F101
TM 5051-10

RESISTOR COLOR CODES



COLOR	SIGNIFICANT FIGURE	MULTIPLYING VALUE	TOLERANCE (%)
BLACK	0	1	± –
BROWN	1	10	± 1
RED	2	100	± 2
ORANGE	3	1,000	± 3
YELLOW	4	10,000	± 4
GREEN	5	100,000	± 5
BLUE	6	1,000,000	± 6
VIOLET	7	10,000,000	± 7
GRAY	8	100,000,000	± 8
WHITE	9	1,000,000,000	± 9
GOLD	—	0.1	± 5
SILVER	—	0.01	± 10
NO COLOR	—	—	± 20

NOTES

* INSULATED FIXED COMPOSITION RESISTORS WITH AXIAL LEADS ARE DESIGNATED BY A NATURAL TAN BACKGROUND COLOR NON-INSULATED FIXED COMPOSITION RESISTORS WITH AXIAL LEADS ARE DESIGNATED BY A BLACK BACKGROUND

† RESISTORS WITH AXIAL LEADS ARE INSULATED. RESISTORS WITH RADIAL LEADS ARE NON-INSULATED

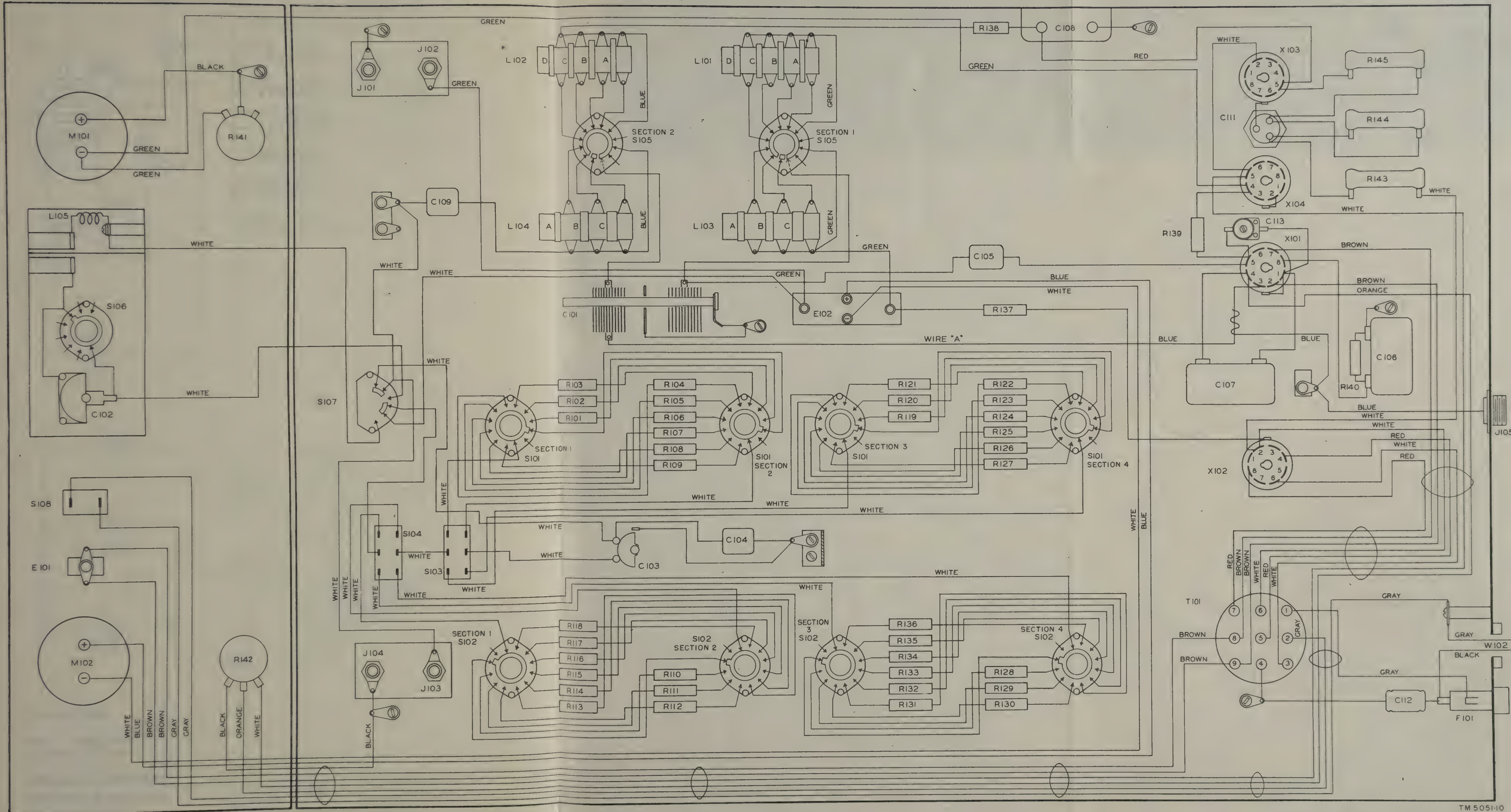
RMA RADIO MANUFACTURERS ASSOCIATION

JAN JOINT ARMY-NAVY

THESE COLOR CODES GIVE ALL RESISTANCE VALUES IN OHMS

TL 32454S

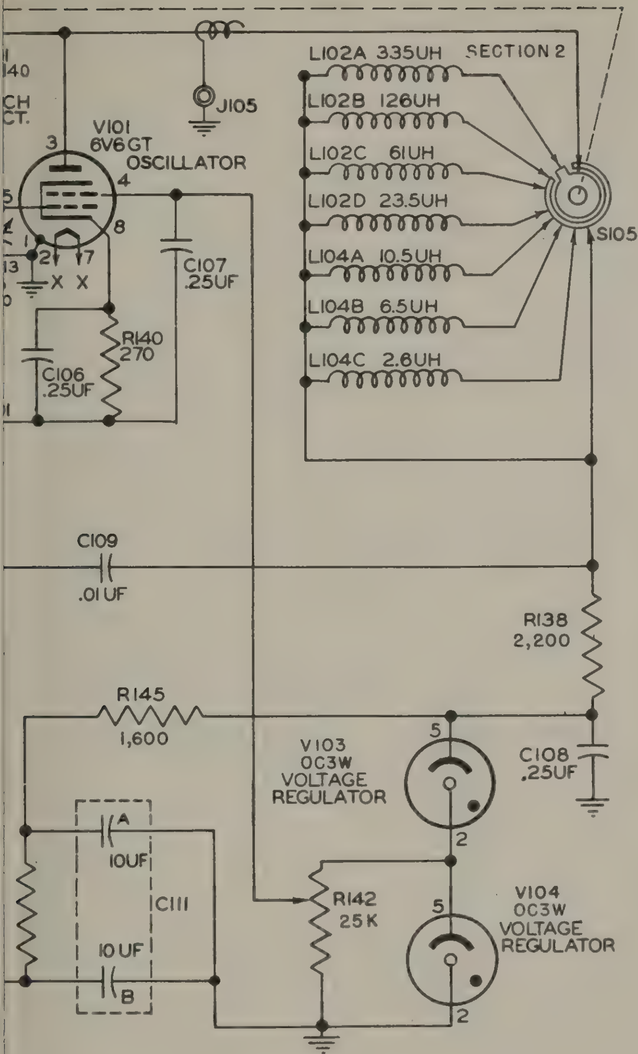
Figure 17. Resistor color codes.



TM 5051-10

Figure 18. Wiring diagram.

939772 O - 51 (Face p. 64) No. 1

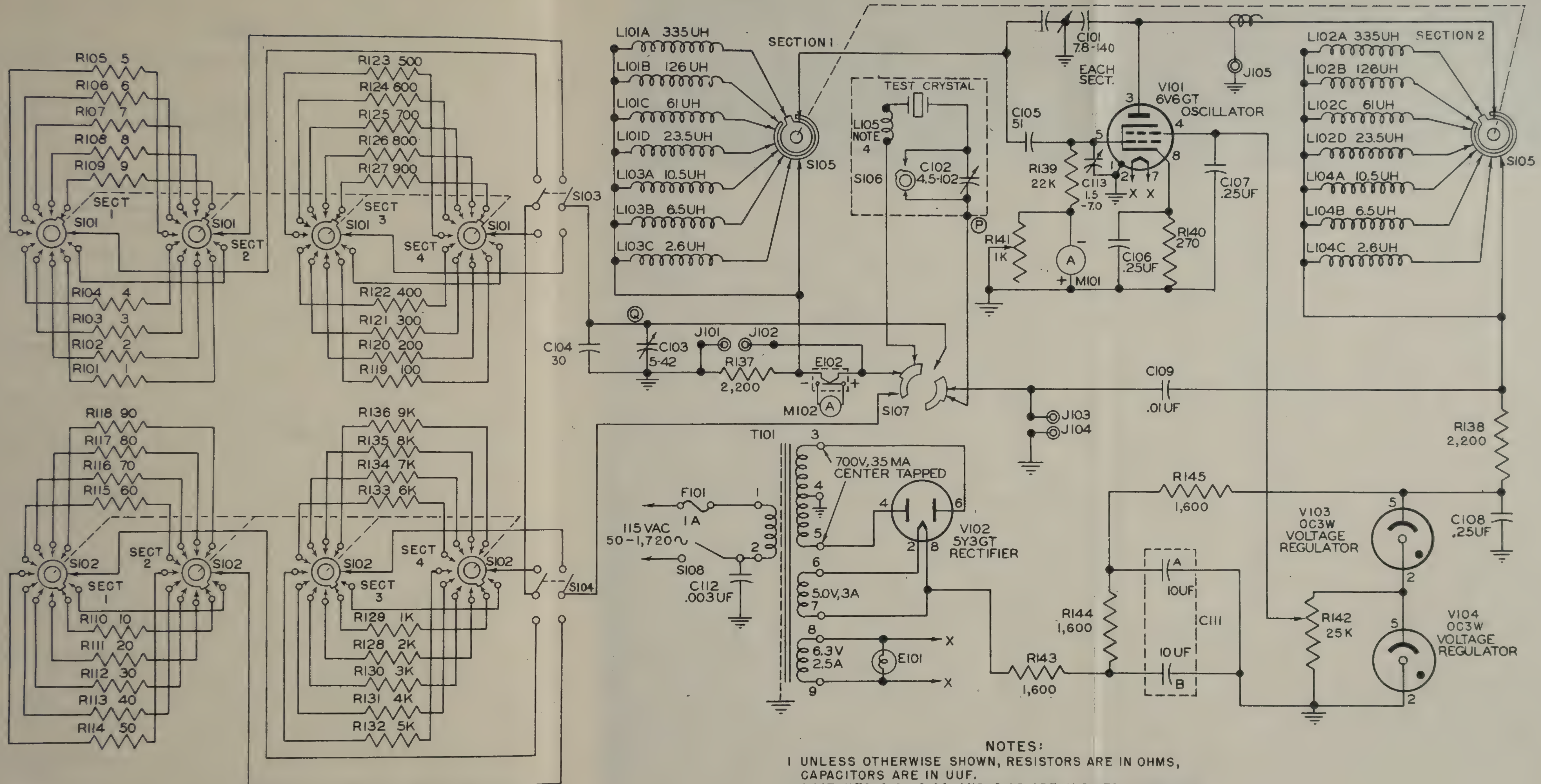


RE IN OHMS,

WED FROM END
SIGNATED "1" ARE

ERANCE RESISTORS.
MPEDANCE METERS.

TM 5051-12



NOTES:

1 UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2 SWITCHES S101, S102, AND S105 ARE VIEWED FROM END OPPOSITE CONTROL KNOB; SECTIONS DESIGNATED "1" ARE NEAREST THE KNOB END.
3 R101 TO R136 INCL ARE $\frac{1}{2}$ WATT, $\pm$ 1% TOLERANCE RESISTORS.
4 L105 IS NOT PRESENT IN ALL CRYSTAL IMPEDANCE METERS.

TM 5051-12

Figure 19. Over-all schematic diagram.

939772 O - 51 (Face p. 64) No. 2

INDEX

○

T.S.-330

STEP	1.	1,00 – 1,50 MC ([illegible])	335 μH
"	2.	1,50 – 2.25 MC ([illegible])	126 μH
"	3	2,25 – 3,40 MC ([illegible])	61 μH.
"	4	3,40 – 5,10 MC ([illegible])	23.5 μH
"	5	5,10 – 7,50 MC ([illegible])	10.5 μH.
	6	7,50 – 10 MC ([illegible])	6,5 μH
	7,	10.00 – 15.00 ([illegible])	2.6 μH.

TO CALIBRATE AND MAKE NEW CURVE ON KIND CAPACITOR PLACE [illegible] ON CALIBRATE. SWITCH S106 ON A. CLIP ONTO CAPACITOR C102 AND MAKE NEW CALIBRATION CHART.

30 mH
10.9 mH
5.4 mH
2.2 mH.
.93 mH
.41 mH.

δ γ time on f^2 item

5C

$\angle$6C

570

STEP 1